Social and Environmental Impacts of Climate and Ecosystem Change in the South African Langkloof

Arjan de Groot
MSc Thesis in Climate Studies
June 2015

Supervised by: Dr. André van Amstel (ESA)
Dieter van den Broeck (Living Lands)
Course Code: ESA – 80436

Environmental Systems Analysis

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Preface

This thesis was the product of my deep personal interest in integrated research that combines environmental and social issues. To this end, I established contact with the South-African based organization Living Lands, which have a history in facilitating and enabling master theses. It was agreed that this thesis was to be part of a larger assessment that Living Lands wants to conduct in the Langkloof. Little concrete information is available about this area yet, and the goal of that assessment is to receive a thorough understanding of the main environmental and social issues and happenings, and to obtain information regarding the economic development of the fruit farming industry in the study area. My thesis contributes to the first objective, namely to identify and analyse the main environmental and social issues, and to provide insight in the most important stakeholders in the area and their views on these issues. In order to cover the second objective of the larger assessment (i.e. the fruit farming industry), another student, Amilcar Guzmán, from Wageningen University participated in this project. To facilitate effective field research, Amilcar and I collaborated during the writing of the proposal and during the field work in South Africa. As both our theses aimed to contribute to the objectives of Living Lands' intended assessment, we both developed and conducted interviews together. As the study area was identical in both theses, the information provided in chapter 2 (study area) and Appendix 1 (detailed information about the study area) was a combined effort of Amilcar and me. Due to the goals of Living Lands, the intended scope of the research, and the limited time available, it was agreed with Living Lands to focus on an 'understanding' of the area. This referred to the provision of an 'overview' of the main issues, trends and challenges, rather than to attempt to address a small number of specific issues in greater detail. As such, this study is of a more qualitative than quantitative nature.

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Abbreviations

GIS	Geo-Information System
BEE	Black Economic Empowerment Act
BMR	Baviaanskloof Mega Reserve
CAPE	Cape Action Plan for the Environment
CFR	Cape Floristic Region
DFF	Deciduous Fruit Farmer (INTERVIEWED)
DWAF	Department of Water Affairs and Sanitation
EFA	Ecosystem Function Analysis
EXP	Expert (INTERVIEWED)
GOV	Governmental Representative/Actor (INTERVIEWED)
IAP(s)	Invasive Alien Plant Species
IEA	Integrated Ecosystem Assessment
WfW	Working for Water

Glossary

Agricultural Practice(s)	Activities carried out by farmers to enhance, prepare or produce agricultural goods
Invasive Alien Plant Species	Invasive plant species not endemic to South Africa and with significant environmental impact
Climate Change	Ongoing process of climate change in regards to the next 20-80 years
Commercial Farmer	Deciduous fruit farmer with international and national exports
Deciduous Fruit(s)	Assortment of pome and stone fruits that are produced in the Langkloof and exported
Ecosystem	System involving the interactions between living organisms and its nonliving environment in a particular area
Ecosystem Function(s)	Function of an ecosystem that enables, amongst others, services with a direct or indirect benefit to humans
Ecosystem Process(es)	Physical, chemical and biological processes that link organisms and their environment
Ecosystem Service(s)	Benefits that humans directly or indirectly receive through ecosystems
Land Degradation	Manmade degradation of nature through overuse of natural resources or removal of natural vegetation
Living Lands	South Africa based environmental non-profit organization for conserving and restoring living landscapes
Natural Resource(s)	A material or immaterial benefit for humans that is found in nature
Stakeholder	Actors in an area with decision-making power, that are heavily affected by an issue, or have knowledge about an issue

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Summary

The Kouga catchment area and the Langkloof valley with its favourable climatic conditions is an important agricultural production area. The valley is the largest producer of deciduous fruits in the Eastern Cape region and its inhabitants are the first beneficiary of its different ecosystem services. Water from the catchment is essential for their settlements and the deciduous fruit farmers. The catchment also provides a habitat for important endemic plant and animal species. As a result of these conditions, the population and agricultural production is increasing in the valley, and the population is growing. Nevertheless, this growth also increases social tensions and environmental stress. Nature is degraded in many places, and water supply is constrained. This causes conflicts and intensifies tensions between fruit farmers and the municipality. Furthermore, invasive alien plant species have invaded the area and are rapidly spreading, and extreme weather events threaten agricultural production and people's livelihoods. Finally, the effects of climate change could further exacerbate these trends.

This thesis provides an overview of the many social and environmental issues that are currently and potentially affecting the valley, and addresses the future impacts and implications of a climate change in the region. To solve and adapt to these problems, ,this research assesses the current situation and delivers a robust analysis of possible future developments and impacts. The relationship between, and the needs of stakeholders are examined.

The research methodology consisted of an integrated ecosystem assessment (IEA) to assess the state and relative importance of ecosystems and their services. A stakeholder analysis provided information on local stakeholder's needs, importance, connections, perceptions, tasks, activities and problems. The research focuses on two main stakeholder groups: fruit farmers and government representatives, but also included opinions of local experts and addresses other stakeholder's needs. Furthermore, a climate change impact analysis assessed the social and environmental impacts of climate change. The necessary data for these methods were collected through stakeholder interviews, stakeholder meetings, existing literature and available databases, and through field observations.

The future supply of important ecosystem services (such as the provision of water, the moderation of extreme events and the climate and water regulation ability) are likely threatened and require immediate attention. Especially water is a limiting resource, and the competition for water between the fruit farmers, the municipality and the downstream water users further complicates the issue. The spreading of invasive alien plant species also reduces water availability and these issues need to be addressed by, for example, increasing the effectiveness of the Working for Water Program. All these issues will likely be further exacerbated by climate change. Current projections indicate a rise of temperatures in the area of 1.5 to 2.5°C within the half century. Furthermore, weather variability will probably

increase, and the occurrence of extreme weather events, such as hail, droughts and flood likely become more frequent.

The local environmental conditions threaten the foundation on which agricultural production and the livelihood of people heavily depends. Fruit farming is the major economic activity and employs approximately 80 % of the population. Moreover, most available water is used to irrigate and produce fruits. Climate change or reduced water availability would almost certainly have negative consequences for fruit production. Hotter temperatures and fewer winter nights with freezing temperatures challenge for agriculture and thus also threaten the livelihood of many families. However, windows of opportunities emerge when, as projected, rainfall slightly increases. Similarly, the government also faces many future environmental and climate change challenges. The South African government officially owns all water rights, enforces laws and regulations, and should mediate between people and industries. Additionally, the local municipality is mandated to provide for its citizens and is thus in charge of managing the valley's ecosystems and people's livelihoods. As such, the rapid population growth in the area, the water shortage and the conflict with deciduous fruit farmers are concerns. Mistrust exists between the government and the fruit farmers as each party believes that the other is uncooperative and they accuse each other of only looking after their own problems.

Opportunities to adapt to future problems include a better cooperation between the various stakeholders. This first of all requires the development of mutual trust. Collaborative efforts should strengthen the region's resilience, and a first step into the right direction would be for all stakeholders to participate in a collective water forum, which is currently being established. In this, the Living Lands organisation (for which this research has been conducted) could facilitate and mediate between the municipality, the government and the fruit farmers. To repair and replace old and inadequate infrastructure is also necessary as less water leakages and an improved ability to store water during intense rain events would increase water availability. To do this, more funding is needed. Future projects could target infrastructural development first. New fruit varieties that are better adapted to a warmer, more variable climate and that require fewer freezing nights, are also a sensible agricultural adaptation to climate change.

1 Introduction

1.1 Background

Humans have always made use of nature and have harvested its resources to further their own needs. Human overexploitation and encroachment of agriculture and cities of pristine ecosystems have taken their toll (Crutzen, 2006). In recent years, many natural resources are increasingly exploited in order to satisfy the demands of a growing world population (Lant *et al.*, 2008). As a consequence, many ecosystems on Earth are seriously threatened. For decades now there has thus been an increasing concern in terms of sustainability, preservation and restoration of ecosystems. Future generations are in danger of facing shortages in natural resources (Costanza *et al.*, 1998). These concerns gave rise to the study of ecosystems and their services. An ecosystem service can be defined as a function of an ecosystem that delivers a direct or indirect benefit to humans (Millennium Ecosystem Assessment, 2005). Studying the mechanisms, dependencies and interrelationships between different forms of services in an ecosystem allows for better understanding of these services and their benefits, and will thus enable humans to better manage, use and preserve endangered ecosystems.

South Africa has a rich nature and is one of the most bio-diverse countries on Earth. It has been classified as the country with the third-highest level of bio-diversity, containing approximately 18,000 species of vascular plants and many endangered animal species, such as the White and Black Rhino (Crane, 2006). A reason for this high bio-diversity is the fact that most of the country is situated on a high plateau, while being influenced by the relatively warm Indian Ocean to the east and the cold Benguela current to the west (Walker, 1990). As a result, many regions in South Africa are subjected to unique climate conditions, which lead to the existence of nine different biomes, home to many unique species (Mucina and Rutherford, 2009). However, South Africa is currently facing the highest extinction rate in species worldwide (Crane, 2006), and 40 % of its terrestrial ecosystems are being categorized as threatened (Driver *et al.*, 2011). Different factors contribute to this environmental degradation, such as the influence of agricultural practices, climate change and invasive alien plant species.

Recognizing this threat to its natural capital, South Africa has recently taken actions to preserve and restore its ecosystems and their services. In 1995, South Africa signed the Convention on Biological Diversity with the goal of conserving its native biodiversity and promoting a sustainable and more efficient use of its ecosystems (South African National Report on the Convention on Biological Diversity, 1998). Furthermore, under the National Biodiversity Strategy and Action Plan (NBSAP, 2005), five strategic objectives are carried out with the aim to build a coherent policy and institutional framework for biodiversity management. Its goal is to better manage terrestrial and aquatic ecosystems, and to use biological resources sustainably in order to solve the many challenges that humans and ecosystems in South Africa currently face. Being a relatively dry country and being highly dependent on the use of water for its important agricultural sector and for its growing population, South Africa places a high importance on the management and preservation of water resources. Invasive alien plant species (IAPs), many originating from Europe or Australia, are further exacerbating the environmental problems (Görgens and van Wilgen, 2004). These IAPs are out-competing the native flora in many regions and generally require larger amounts of water. To help alleviate these issues, South Africa started the Working for Water (WfW) program, which aims to clear alien plant species and so restore and preserve the native vegetation. However, perhaps due to the resilience of IAPs, progress is generally slow, and in many cleared areas these exotic plant species reappear quickly (McConnachie *et al.*, 2012).

Large-scale agricultural farming is putting further stress on the land and its ecosystems. Native vegetation is being cleared and large amounts of natural resources are used for the agricultural sector (Hoffman and Ashwell, 2001). Additionally, natural disasters have been affecting the nature and its inhabitants in South Africa for decades already, but there may exist a worrying trend in so far as that more disasters may occur in shorter time periods nowadays, perhaps caused by a more degraded and less resistant vegetation, as well as due to the impacts of ongoing climate change (Mason *et al.*, 1999). Severe floods, droughts and hailstorms have occurred numerous times in the last decade in the Eastern Cape region, often with devastating consequences for agricultural harvests and large damages to infrastructure.

In order to better deal with these issues, partnerships for restoring nature and its ecosystems, and agreements to better manage agricultural impacts are beginning to take root and need to be further facilitated. This is only possible if all stakeholders collaborate with each other and exchange information and expertise amongst each other. Communication between different types of stakeholders is one of the major barriers when it comes to solving complex environmental issues that influence many different social and ecological spheres differently (den Exter, 2004). The South African government, national and international research institutes and businesses, land-owners, and local stakeholders all need to work in cooperation and mutual understanding with each other in order to successfully reach the ambitious goals that have been set by the South African government.

1.2 Problem Statement

The South African organisation Living Lands has been actively restoring landscapes and facilitating communication and cooperation between local stakeholders. After having worked primarily in the Baviaanskloof, the organization now also wants to become active in the Langkloof. Hence, the interplay of social and environmental issues and their potential and existing impact on the various stakeholders in the Langkloof is the subject of this thesis.

Some of these issues are of ecological, some of social, and some of economic nature. This results in a complex situation where it is imperative that all issues are examined from different viewpoints at all times. This is called an integrated analysis.

The rich biodiversity and the ecosystems in the study area are threatened and in many cases already severely degraded. Alien invasive plant species, unsustainable land use, and overgrazing are part of the pressures leading to this situation, but at the same time present a unique challenge in itself (Skowno, 2008).

Floods, droughts and hailstorms have been historically registered in the area and have caused large damages to agricultural production and infrastructure. Furthermore, the current land degradation leads to an increased vulnerability to natural disasters (Jansen, 2008), and higher temperatures and increased rainfall variability influenced by climate change can increase the frequency of such events (Jansen, 2008; Vromans *et al.*, 2010). These issues have manifested itself in recent years in the forms of severe floods in 2006 and 2007, serious droughts in 2008, 2009 and 2010, and devastating hailstorms in 2010 and 2014. Moreover, the potential effects of climate change in the region and on its ecosystems are not well studied and can result in further intensification of the problem. Especially due to the inherent uncertainty attached to climate change, to prepare for or prevent natural disasters is difficult for stakeholders, unless they have access to relevant information and forecasts.

The availability of water and the use of it is another complex issue that is present in the Langkloof valley. Commercial farmers need the water for the irrigation of their orchards, whereas the municipality requires the water for the livelihoods of people in the settlements. Oftentimes, these two are in direct competition when it comes to water supplies, and water rights are often outdated. Furthermore, since the Kouga catchment supplies water to the Kouga Dam, and by extension to the Gamtoos valley and the Nelson Mandela Bay Metropolitan Municipality (Port Elizabeth), not only local ecosystems and agricultural practices are affected. Impacts on downstream users which extend beyond the study area need to be considered as well. The Gamtoos valley has need of the water for agricultural and livelihood purposes, whereas Port Elizabeth is dependent on the water from the catchment as drinking water and for industrial activities (Jansen, 2008).

Given the relative scarcity of water in South Africa, due to the involvement of many stakeholders from the Langkloof, the Kouga catchment and the downstream regions, water issues are clearly complex and require communication and cooperation between farmers, municipalities, businesses and the national government. Additionally, there are several business sectors and stakeholders who are potentially or currently affected, given their dependence on the landscape's ability to provide other important ecosystem services. This means that many different actors are involved and have a stake in the ecosystem services provided by the Kouga catchment.

Labour unrest, poverty, inequality and inadequate infrastructure are other manifested forms of social problems in the Langkloof valley that need to be addressed.

In order to tackle the environmental issues, restoration initiatives in Fynbos, Thickets and wetlands are regarded as a potential solution for land degradation and water shortages in the area. It also provides an opportunity for adaptation to current and future impacts of climate change (Jansen, 2008; Vromans *et al.*, 2010). Thus, incorporating climate change into the analysis, as well as aiming at discussing partnerships for landscape restoration and addressing measures of adaptation is important. Examining the social nature and complexity of problems is helpful in order to better approach a possible solution to these issues.

1.3 Research Objective and Questions

As requested by Living Lands, this thesis research aims to provide a thorough overview of the different environmental and social issues and on the primary stakeholders in the Langkloof area. This includes an analysis of the state of climate- and ecosystem change, and their respective effect on the area's various stakeholders, as well as an identification of opportunities for adaptation. The thesis will provide a basis on which future projects and stakeholder activities can be launched. This thesis will be largely qualitative, although quantitative data is used wherever possible and available. The large extent of the area, the remote location, the plans for social development, the aforementioned environmental problems and the research challenges foster the need for an integrated research. Thus, the aim is to not only consider an ecological view of the problems, but to also examine social aspects and needs.

The objective is addressed through six research questions related to the connections between ecosystem services, stakeholders and climate change, and are formulated below:

1. What is the state of the ecosystems and their services in the Langkloof, what are their benefits and beneficiaries, and what are the main environmental issues?

2. How can current and potential future climate change impact the Langkloof region?

3. What are the risks of possible changes in ecosystem services for the relevant stakeholders?

4. What are the needs and interests of the main stakeholders in the Langkloof and what are the main social issues present?

5. What is the relationship between stakeholders in the Langkloof and what is their perception on different social and environmental issues?

6. What are adaptation opportunities to environmental risks for stakeholders in the future?

The information gathered to answer these questions will provide Living Lands, local businesses, researchers and decision-makers a possibility to make informed decisions on how to approach the various social and natural issues and solve them.

1.4 Outline of the Report

I will first introduce the study area in Chapter 2. Next, the various methods that were used during the research are discussed in chapter 3. Following that, chapter 4 will present an overview of the different ecosystem services that are present in the Langkloof, as well as their benefits to stakeholders and their current and future use. After that, chapter 5 consists of an analysis of the climate change in South Africa and the study area. Current and future trends in climate will be mentioned, as well as what effects these changes may have. Chapter 6 will reflect a stakeholder analysis, and will thus detail what concerns the various stakeholders may have, and what issues they are currently facing. First, the chapter will address the deciduous fruit farmer, followed by the government representatives, and lastly the views and opinions of experts from the area will be presented. After that, Chapter 6.4 will first identify certain key issues, and afterwards discuss these issues in greater detail. Chapter 7 is a discussion of the various methods that were used and of the results that were presented in the earlier chapters. Chapter 8 will then conclude and demonstrate that solutions need to be found and implemented quickly, if a negative development in the area is to be avoided. Lastly, opportunities for adaptations are shortly discussed in a recommendations section.

2 Study Area

This study focuses on the Langkloof, an agricultural valley situated in the Eastern Cape province of South Africa. The topography in this area is rugged and its spatial boundaries are naturally demarcated by mountain ranges (Haigh *et al.* 2004). The Langkloof belongs to the Kouga catchment area, which covers approximately 282,000 ha and extends from the township of Avontuur in the west up to the Kouga dam in the north-east (Mander *et al.*, 2010; *Figure 1*). Despite the large extension of the Kouga catchment, mountainous areas cover the majority of its surface (248,000 ha) (Mander *et al.* 2010).

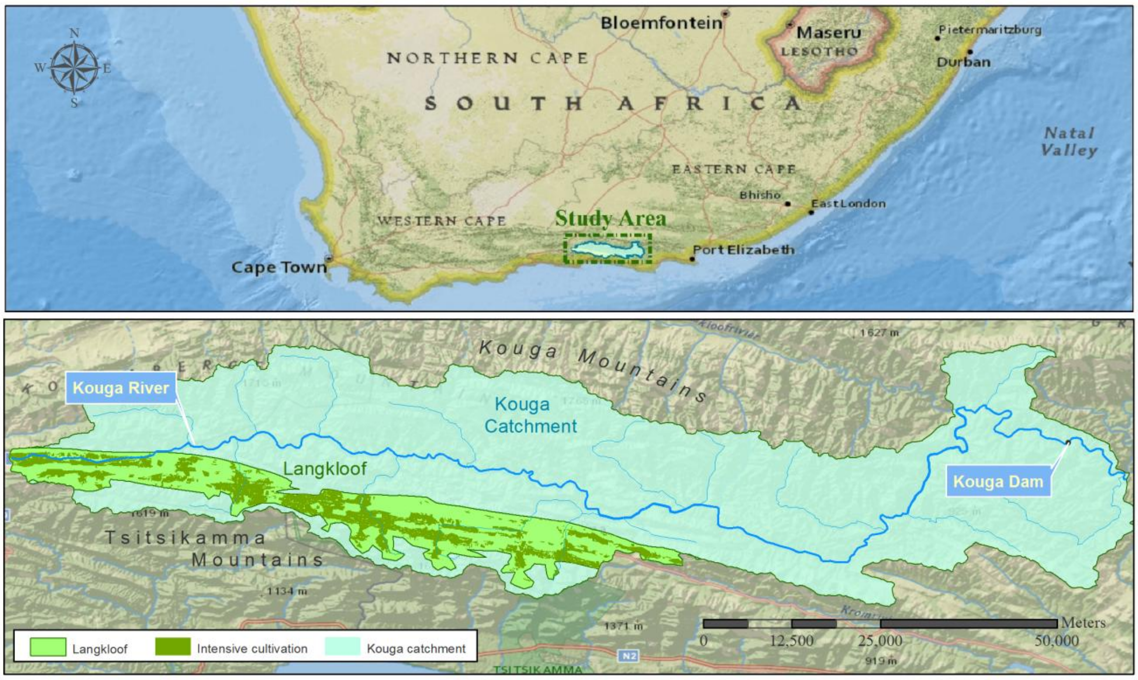


Figure 1. **Overview of the study area**

Approximately 15,000 people live within the catchment, although the numbers are almost certainly higher today, due to expansion of various settlements (Government representative (GOV) 1). Most of this population is concentrated over a total of eleven settlements, which developed next to the different Kouga River tributaries in the Langkloof. These settlements extend from west to east in the following order: Avontuur, Haarlem, Ongelegen, Misgund, Apiesrivier, Louterwater, Krakeel, Joubertina, Ravinia, Twee Riviere and The Heights, of which Haarlem, Misgung, Louterwater, Krakeel, Joubertina and Twee Riviere are the largest settlements. Avontuur and Haarlem are part of the George Municipality in the Eden district, and thus fall under the jurisdiction of the Western Cape, whereas the other settlements belong to the Koukamma Municipality in the Sarah Baartmann district of the Eastern Cape. *Figure 2* illustrates the main townships and the adjacent tributaries of the Kouga River in the Langkloof.

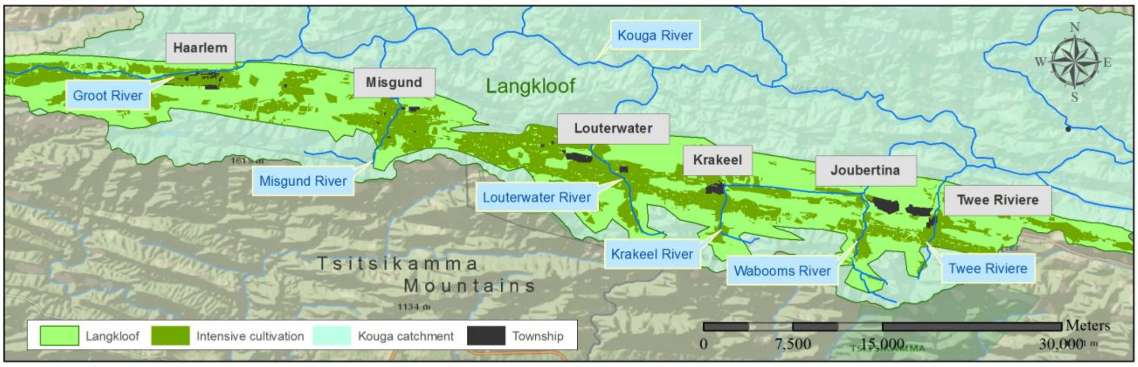


Figure **2. Main townships and tributaries of the Kouga River in the Langkloof**

This thesis focuses on the section of the Langkloof that begins approximately 12 km to the west of the township of Haarlem, at the township of Avontuur on the national route 62. The Tsitsikamma Mountains (in the south), and the Kouga and Suuranys Mountains (in the north) determine the boundaries of the study area. The small settlement of The Heights demarcates the eastern border of this area. For cartographical purposes, this study relies on the definition of Broad Habitat Units (BHU) provided by the Cape Action Plan for the Environment (CAPE) (Boshoff *et al.*, 2002; Younge and Fowkes, 2003) specifically defined as Langkloof Fynbos / Renosterveld Mosaic, which is only used as a surrogate for the estimation of areas given the lack of more precise spatial representations of the valley. Based on this reference map and the boundaries of the Kouga catchment, the extension of the Langkloof in the study area is estimated at 42,274 ha.

Although the valley's extension in the Kouga catchment is relatively small, there is intensive agriculture and its soils and water, stemming mostly from the tributaries of the Kouga River, represent valuable resources for the local livelihoods. The main agricultural crops in the Langkloof valley are deciduous fruits (Jansen, 2008), of which it is the second largest producer in South Africa (Hortgro, 2014). While only 4 % of South Africa's GDP is attributed to agricultural production, the agricultural sector still accounts for over 10 % of the country's total employment, and one third of its production is exported (Calzadilla *et al.*, 2014; OECD Review of Agricultural Practices, 2008).

Approximately 150 farmers are currently active in the Langkloof, with around 20 of them owning more than one farm (Veerkamp, 2013). Many of these farms have existed for generations already, and have often stayed within the family, being given from father to son. It is for this reason as well that the farmers in the Langkloof know each other well and often share knowledge and information between each other, as they can draw on a generation-spanning experience of fruit farming in the Langkloof area.

While each farmer has its own irrigation dam for additional water storage, there are four larger dams in the area that supply water for the settlements and the agricultural practices. The irrigation boards of Haarlem and Louterwater own private communal dams, whereas the local municipality in Joubertina owns the dam in the Waboms River (see *Picture 1*).

Picture 1. Overview of the three completed larger dams in the Langkloof valley. a) the Wabooms River dam was constructed in 1988 and has a storage capacity of 0.185 million m³. b) the Louterwater dam is the smallest of the three dams and also experiences problem with water quality. c) the Haarlem dam is the largest of the three and has a storage capacity of ~4.5 million m³. Photo Source: Author

Furthermore, the settlement of Misgund has recently finished the construction of its own dam, although pipelines from the dam to the settlement and farmers still have to be installed by the municipality (Deciduous Fruit Farmer (DFF) 4). After the end of the apartheid in 1994, the municipal structure throughout South Africa began to change. In 2000, there was an act of dispensation issued by the national government. Throughout South Africa, the number of municipalities decreased from 800 to 200. In the Langkloof, the municipality of Joubertina was merged with the Kareedouw municipality to make up the larger municipality of Koukamma. Also, the Black Economic Empowerment (BEE) act, agreed upon in 2001, was launched by the national government in 2003 and promoted economic privileges for certain disadvantaged groups (Broad-Based Black Economic Empowerment Act, 2003). Through this act, about 80 emerging farmer projects were started in the Langkloof. These emerging farmers receive assistance from the government in terms of financial support and start-up, and some have a more experienced, often retired commercial farmer as a mentor. These mentors often introduce the relatively inexperienced emerging farmers to fruit farming and share their expertise and knowledge (GOV 8).

Even though this thesis focuses on activities in the valley, the contribution of the mountainous areas in the Kouga Catchment for the area of interest is undeniable. Therefore, some of the analyses presented in this report may refer to ecosystems from the entire Kouga catchment, as they are directly supporting the provision of specific services in the Langkloof valley.

3 Methodology

In order to answer the formulated research questions, this study will address the climate, the ecosystems and their services in the Langkloof area through an Integrated Ecosystem Assessment (IEA). A focus will be on how deciduous fruit farmers deal with environmental problems in the area, and how they can adapt to climate change. The interest in this particular business sector and stakeholder arises from their vulnerability to climate and ecosystem change, as well as their dependency on many ecosystem services. Furthermore, the deciduous fruit farming industry is the largest industry in the Langkloof, and is therefore the most important economic asset of the area, and provides employment for a majority of its inhabitants. The methodology to address each specific part is separately described in the following sections.

3.1 Integrated Ecosystem Assessment

The main framework that was followed in this research was an integrated ecosystem assessment (IEA). It is a multidisciplinary approach to assess the state and importance of an ecosystem for a region. It has become a powerful tool to analyse and highlight complex environmental issues, and to link them to a social context. The approach that was followed in this research has been visualised in *Figure 3*. External drivers, such as climate change and land use can both influence the structure of an ecosystem. Furthermore, land use change also has an influence on climate change, as greenhouse gas (GHG) emissions can easily accelerate climatic warming for instance. Ecosystem and biodiversity encompass the functions and structures in an ecosystem, and a human wellbeing is here influenced by benefits that humans receive from ecosystems. The process is thereby, that a biophysical structure, such as the presence of vegetation for example, provides a function, which provides the capacity for an ecosystem to produce a service. These services (e.g. provision of food or climate regulation) can result in direct and indirect benefits to humans, which can then be expressed in values. Through understanding and properly acknowledging the importance of ecosystem services, humans can then use this information to adjust their land use in order to reduce their impact on the biophysical structure of ecosystems.

When conducting an IEA, it is important to not only address an ecosystem service by itself, but also to consider the functions and processes that enable the provision of each service, and to take into account external drivers of change. This research focused on identifying and discussing the drivers, the various ecosystem services in the area and their importance to the different stakeholders in the area. It was of primary importance to identify causal link and to address the social and environmental impacts of various issues, as well as their development in the future. In this research, the IEA encompassed an ecosystem function analysis, an ecosystem services assessment, a stakeholder analysis, a climate change analysis, and an analysis of the risks and opportunities.

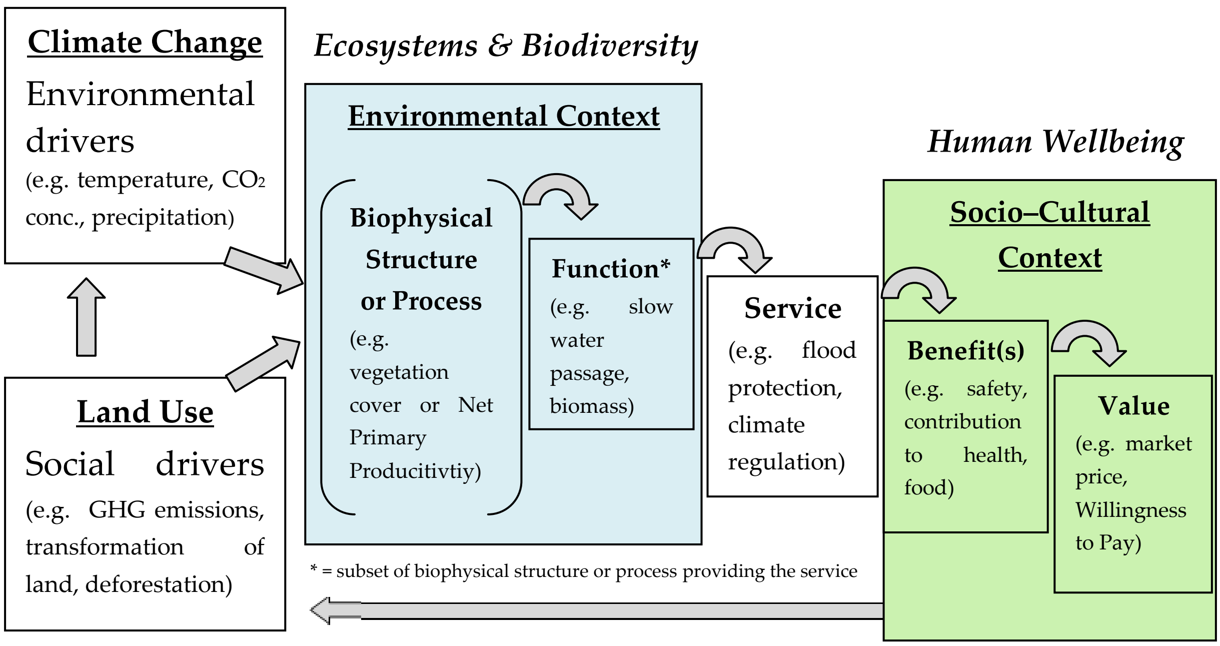


Figure 3. **Cascade framework linking climate, ecosystem and human wellbeing (modified from De Groot *et al.*, 2010, and adapted from Haines-Young and Potschin, 2010).**

3.1.1 Ecosystem Function Analysis

An ecosystem function analysis (EFA) is a prominent method for evaluating the state, the processes and the dependencies of an ecosystem. It serves to give reliable and important information about the health of an ecosystem through identifying and examining effects of stress and other disturbances, and explains the functions that allow an ecosystem to provide services. The EFA model is composed of three inter-related parts, which all need to be considered and all interact with each other (Tongway and Hindley, 2004):

- Landscape Function Analysis (LFA)
- Vegetation and Structure Composition
- Habitat Complexity

The EFA was applied in a more qualitative nature, due to the lack of time to collect quantitative data. Reliable and meaningful measurements on site would require a large amount of time and effort. However, qualitative information about ecosystem stability, soil composition, and water and nutrient cycling is very helpful in understanding the provision of crucial ecosystem services, and how to preserve them. Considering the most important aspects of an EFA allows to better understand the complexity of ecosystems. Most of this information was obtained through a literature review (e.g. Mucina and Rutherford, 2009; Veerkamp, 2013), although observations and interviews in the study area helped to complete the picture and provided meaningful information as well. The vegetation cover plays an important role for the preservation and maintenance of an ecosystem, through providing food and habitat for other biota. A habitat analysis includes research on the species living in a habitat. The flora and fauna of a region is of great importance for ecosystem services, as many of the services are directly or indirectly relying on interactions with and between fauna and flora species, and they can have an important impact on human land use.

3.1.2 Ecosystem Services Assessment

Ultimately, an ecosystem service analysis aims to deliver information about the benefits to human society that an ecosystem provides (de Groot *et al.*, 2002). As scientific research has become more aware of the importance of ecosystem services to humans, so have ecosystem services become more important in decision-making processes as well. The Millennium Ecosystem Assessment (MEA, 2005) and The Environmental Economics of Ecosystems and Biodiversity (TEEB, 2010) are the most important publications on the terminology and characterization of ecosystem services. Both studies divide ecosystem services into Provisioning, Regulating and Cultural Services. The terminology used in this research follows the terminology of the TEEB study, which is why 'Habitat Services' are included here. Habitat Services, as used by the TEEB study (2010), are a subset of supportive services that have an economic value in their own right through nursery (habitats for species) and genepool protection (genetic diversity) benefits.

Provisioning Services are services of direct use for humans. Examples include the provision of food, water or raw materials. Regulating services are those services that have a more indirect use to humans. They regulate and maintain functions in an ecosystem or provide for example water regulation, erosion control, pollination and climate regulation. Cultural services are of an indirect use to humans and cannot be expressed in monetary values. These services are non-materialistic and can include aspects such as recreation, awareness and spiritual values. Supporting services, as mentioned earlier, are so-called "life-support" systems that are needed if an ecosystem is to preserve itself and its functionality over a long period of time. Examples here are the formation of soil, nutrient cycling and biodiversity. As discussed earlier, habitat services can be seen as a subset of supportive services. They obtain their importance through providing benefits in terms of nursery services (habitats for species) and genepool protection (genetic diversity).

In the study area, some ecosystem services are of higher importance than others. These include the provision of food (in terms of agricultural crop production and meat), provision of water, provision of raw materials (for building and fertilizer), regulation of water (water availability), mitigation of natural hazards, prevention of soil erosion, pollination, biological control, and lifecycle maintenance. All of these services are prominent in the Kouga and upper Kromme catchment areas and were examined in detail.

Conducting an ecosystem service analysis will further help to facilitate better communication between stakeholders by informing them about the dependencies and mechanisms between services and their preservation and provision. Only if all relevant stakeholders are aware of these connections can fruitful communication take place, and can successful measures be undertaken. Due to time constraints, the ecosystem services assessment is focussing on qualitative results. It was not possible to calculate economic values for the ecosystem services, but stakeholders in the area were questioned on their view concerning the relative importance of various services.

3.1.3 Stakeholder Engagement and Analysis

The state of ecosystem services and the many issues that the environment in the Langkloof, and by extension, the Kouga catchment area, are exposed to, have a direct and indirect effect on many stakeholders. Stakeholders are those entities that are affected by an activity or an issue, or have a direct influence over it (Hage and Leroy, 2007). Local settlements and small land owners are for example directly dependent on the region's ecosystems. They live off and with the land, its vegetation and its animal species. Larger land owners and international corporations and businesses also have a direct interest at stake, as they own much of the agricultural area in the region. Furthermore, the Kouga catchment is the most important water catchment area for the Port Elizabeth region (McConnachie *et al.*, 2012), which makes it an important issue for the city of Port Elizabeth and various departments of the national government as well. Furthermore, due to its high biodiversity and its unique biomes, the area is also of a cultural and scientific importance. Therefore, also research institutes and non-governmental organizations are concerned about the well-being of the area.

Already it becomes clear that different stakeholders with different interests exist inside and outside the study area. A difference in opinion in some ways is especially likely between the agricultural producers on the one hand, and the municipalities interested in providing adequate living conditions for citizens on the other hand. Another view to take into account is those of researchers and conservationists, who are interested in the conservation and restoration of the landscape. In order to take into account the needs and views of all relevant stakeholders, selecting a variety of stakeholders is imperative, in order to take into account the views of all concerned stakeholders and to mediate between them, as well as provide insights into how their livelihood may be affected in the future. The relationship between various stakeholders and their communication within and between each other was therefore of primary importance.

Without a proper stakeholder analysis, it is almost impossible to arrive at a successful solution that aims to provide long-term benefits for everyone. The main steps in this stakeholder analysis were:

1) <u>Identifying relevant stakeholders</u>
   First, it was determined who a stakeholder is. This was done by studying literature concerning the various issues in the Langkloof, and by consulting the knowledge and expertise of the local non-government organization Living Lands. Afterwards, a

selection of the most relevant stakeholders was made and included those stakeholders that are either living in the area and thus directly dependent on one or more of its functions (i.e. fruit producers, citizens, municipalities, various business and research experts), or have a considerable interest or decision-making power over the area (i.e. various departments of the national government or experts). Unfortunately, it was impossible to consider every single stakeholder or to obtain a statement from everyone; however, representatives or representative groups from all relevant opinions and views were included in the study.

2) Categorizing stakeholders
All available and identified stakeholders were grouped into different categories. Some stakeholders have a higher interest or higher influence than other stakeholders, which is why it was important to consider each stakeholder and approach them according to their need and power. Generally, key stakeholders are those that have a high influence on a given issue, and usually also a high interest. Secondary stakeholders are those that have a high interest, but often lack the power to influence a decision making process. External stakeholders are not directly affected by an issue, but have a high interest. Examples may be research institutes or non-governmental organizations.

3) Involving stakeholders
In this phase, the identified stakeholders were contacted and information was exchanged. Stakeholders were either directly involved in the project through participating in meetings, or were consulted or interviewed, depending on the willingness and importance of each stakeholder. In this research, the contacted stakeholders corresponded to one of three different groups: Deciduous Fruit Farmers, Government Representatives and Experts.

After identifying and contacting the first stakeholders in the field, the snowball method was applied to identify and approach more stakeholders. The snowball method is a popular tool in stakeholder engagement and is a non-probability sampling method. Through this method, future stakeholders were determined by asking already identified stakeholders about their knowledge on potentially important people and organizations. As such, the number of identified stakeholders grows rapidly. The snowball method is time-saving, yet still supplies the researcher with a good sample of relevant and interested stakeholders.

3.1.4 Climate Change Analysis

Climate change is playing an increasingly important role in today's society for a number of reasons. Not only can ecosystems be heavily affected by a change in temperature, precipitation or other climatic patterns, but there are also numerous possibilities in which climate change can have a negative (social and economic) impact on humans. In order to fully understand the complexity of the issue and to better assess future trends for the ecosystems in the Langkloof and its stakeholders, considering climate change is necessary. South Africa has recently been active in researching and preparing for climate change, and predictions for the short and long-term future have been carried out (DEA 2013a and b , DEADP, 2008; Johnston *et al.*, 2011). These and other scientific publications and researches built the basis of this climate change analysis.

Especially fruit farmers, who have to deal with natural hazards and have to think carefully on the varieties of fruit they want to grow in the coming years, can be severely affected by climate change. This is why the views and opinions of experts and stakeholders in the area were also considered in this analysis.

The aim of this analysis was to provide an overview of possible climate scenarios, and henceforth discuss their relative impact on the many stakeholders in the Langkloof area.

3.1.5 The Risks and Opportunities Analysis

The aim of this analysis was to combine the information from the other methodologies, i.e. from the ecosystem services assessment, the stakeholder analysis, and the climate change analysis. Here, relationships and issues between different sectors were taken into account, and it was discussed how ecological changes may affect, for example, the livelihood of the inhabitants of the Langkloof. The section synthesizes the many different results of this research and provides a coherent story as to what could and should happen in the near future in the Langkloof in order to achieve a positive social, economic and environmental development.

Information from all available data sources was applied in this analysis. Scientific literature in the form of climatic and environmental assessments, or the needs of deciduous fruit farmers and of the citizens in the Langkloof, was important. But also the opinions of external stakeholders or interests of the national government and other organizations were considered.

3.2 Data Collection Methods

The collection of large amounts of important data was crucial to this study. Throughout the entire fieldwork research period, the non-governmental organization Living Lands facilitated this process and provided guidance and information. The organization is based in South Africa and has been active in the area for many years already, which is why their expertise was invaluable to this research. Living Lands already have a history in facilitating and assisting previous master theses, which provided further secondary data, as well as useful contacts for this research. Hence, for the primary data collection, this research drew upon the extensive network that Living Lands have created in the area in order to facilitate a first contact and subsequently arrange meetings with stakeholders, experts and businesses.

Different methods were used in order to obtain primary and secondary data. These consist of a literature review, stakeholder and expert interviews, group meetings, and data analysis with geo-information systems (GIS). All these methods are presented in *Table 1* according to the specific research question and the methodological steps they correspond to. Moreover, they are further explained in the subsequent sections. Each methodology is not limited to only answer one specific research question, but rather provides information for many different research questions.

3.2.1 Stakeholder and Expert Interviews

As data from the literature is almost always incomplete and not necessarily perfectly suited for this study, it was imperative to collect additional data during the fieldwork. Interviews with important local stakeholders and experts that are active in the region were an important asset when analysing the various social and environmental issues.

The use of interviews was the main method to collect primary data during the fieldwork. Consequently, structured and semi-structured interviews allowed covering a list of predefined core topics and questions, which provided useful information for analysing the ecosystem services, stakeholders, and risks and opportunities in the area. An interview schedule (Kumar, 2011) with a list of organized questions was developed in order to obtain uniform and comparable data regarding ecosystem services and stakeholder perceptions in the area. Additionally, unstructured interviews were useful to complement that information with topics that are of specific importance to an individual stakeholder (Kumar, 2011).

Finally, when stakeholders or experts interviews were impossible, but their views were deemed important, efforts were made to obtain information through email or phone.

3.2.2 Literature Review and Secondary Sources

Of crucial importance to this study was an extensive and complete literature review. As only three months of fieldwork were spent in South Africa, and due to the fact that the study area is very large, there was not enough time to conduct thorough and meaningful scientific measurements. However, previous studies and research projects providing such data have been published in the literature. Hence, a large amount of required information was readily available from peer-reviewed literature.

In addition to peer-reviewed literature, secondary sources such as government publications, documentation by experts, or earlier studies carried out by Living Lands or other organizations were useful for this research. The gathered data includes climatic measurement series, biophysical information, as well as case studies and spatial data in digital format. The relevant data was carefully selected in order to avoid problems associated to its validity, reliability, availability or format compatibility, which are common in the use of secondary sources (Kumar, 2012).

Table 1. Data collection methods and research questions

Research Question		*Method*	*Data collection method*
1.1	What is the state of the ecosystems and their services in the Langkloof, what are the benefits and what are the main environmental issues?	Ecosystem Services Assessment	Expert interviews Literature and secondary data
1.2	How could current and potential future climate change impact the Langkloof region?	Ecosystem Services Assessment Climate change Analysis Stakeholder Analysis	Expert and stakeholder interviews Literature review and secondary data Observations
1.3	What are the risks of possible changes in ecosystem services for the relevant stakeholders?	Ecosystem Services Assessment Stakeholder Analysis Risks and Opportunities Analysis	Stakeholder interviews Literature review and secondary data
1.4	What are the needs and interests of the main stakeholders in the Langkloof, and what are the main social issues present?	Stakeholder Analysis	Stakeholder interviews Stakeholder meetings Observations
1.5	What is the relationship between stakeholders in the Langkloof and what is their perception on different social and environmental issues?	Stakeholder Analysis Risks and Opportunities Analysis Climate Change Analysis Ecosystem Services Assessment	Stakeholder and expert interviews Literature review and secondary data
1.6	What are opportunities for adaptation to environmental risks for stakeholders in the future?	Risks and opportunities analysis	Stakeholder interviews Stakeholder meetings Literature review and secondary data

3.2.3 Stakeholder Meetings

Through the support of Living Lands, it was also possible to gather additional information through participating in workshops or through attending meetings of stakeholder groups in the Langkloof. This was an important opportunity to collect information and facilitate an exchange of opinions. During these meetings, a mutual learning process was encouraged by conducting semi-structured interviews and attending group discussions (Bradley and Schneider, 2009). An overview and short description of the attendants, the agenda, and the main topic of each of these stakeholder meetings can be found in Appendix II – Stakeholder Meetings.

3.2.4 Observations

Having visited many stakeholders in the study area and having spent numerous days there made it possible to make many invaluable observations. These included observing everyday life of employees or citizens, listening to worries and concerns of by passers, or observing the state of infrastructure and ecosystems in the Langkloof.

3.3 Data Analysis

Finally, the obtained data from interviews were categorized according to the most relevant topics for each research question (Kumar, 2011). As such, with the help of the statistical analysis program SPSS, an overview of each stakeholder group was created in which the answers of respondents were distributed over a number of important topics. This information was then processed, compared and analysed in order to ascertain specific key issues amongst and between stakeholders, based on the number of times an issue was mentioned and on experts' opinions on the subject.

The use of Geo-Information Systems (GIS) for the analysis helped to identify and separate biomes from each other, and provided an indication on the effects of land use and the current state of an ecosystem. Spatial data in digital format was used to draw a bigger picture of the study area, its vegetation and biomes, as well as gave information on the extent of human impact.

4 Ecosystem Services Assessment

As mentioned previously, ecosystems are of key importance for the Langkloof area. They provide vital services that the local citizens and its large agricultural sector depend on, and need to be managed efficiently and sustainably if the Langkloof aims to continue to function as the central hub for agriculture in the Eastern Cape in the future. In order to successfully tackle this challenge, it is necessary to ascertain the various ecosystem services in the Langkloof. Only once it is understood how each ecosystem service contributes to the functioning of the system as a whole can successful measures be applied. It is further of crucial importance that such information is being passed on to the various stakeholders in the area, as their interests, practices, and opinions differ vastly from each other. In the Langkloof, an area that aims to accommodate an influx of new citizens and still maintain its agricultural production while simultaneously struggling with limited water resources and combating extreme weather events, understanding the role of ecosystems and their services can hardly be undervalued. Hence, this section will list the various ecosystems services in the Langkloof, and will give an overview of the benefits that these services provide to different stakeholders.

4.1 Ecosystem Services in the Langkloof

The Langkloof is part of the Kouga Catchment, and as such, is home to many important ecosystem services. According to the TEEB study, ecosystem services are defined as the direct and indirect contributions of ecosystems to human well-being (TEEB, 2010). This definition makes a clearer distinction between services and benefits, compared to the previous notion brought forth by the Millennium Ecosystem Assessment (MEA, 2005), which only defined ecosystem services as the benefits that people can derive from an ecosystem. TEEB categorized the ecosystem services into four services: Provisioning, Regulating, Cultural and Habitat Services (TEEB, 2010).

Provisioning services are defined as the products obtained from ecosystems such as food, fiber, fuel, genetic resources, ornamental resources, fresh water, natural medicines and pharmaceuticals. These products traditionally have a direct use-value, which means the resources are used directly. They are quantifiable, materialistic, and can be put to use in a visible way. As such, often an emphasis is placed on provisioning services, as it is easier to derive a market value for those products and due to the fact that they are quantifiable. Provisioning services usually stem from biotic resources such as plants and animals, but can also include abiotic products such as minerals and stones. For the Langkloof area however, the provision of abiotic products is minor, as there are no valuable mineral resources present.

Regulating services are the benefits acquired from the regulation of ecosystem processes such as air quality regulation, climate regulation, water regulation, erosion regulation, water purification and waste treatment, pollination and more. These services have an indirect use-value, and the resources are thus used indirectly. It is harder to grasp the value of these services as they are at best semi-quantifiable (e.g. the removal of GHG from the air). Measurements of regulating services have increased in the recent past and help immensely in providing a better understanding of the value of these services. Regulating services heavily depend on a sustainable management of ecological processes and biogeochemical processes, and are thus perhaps most severely pressured by human influence and their land-use change. Also, due to its high agricultural production, and hence the high dependence on weather, soil composition, water supply and quality, regulating services are of vital importance in the Langkloof area.

Cultural services are the nonmaterial benefits obtained from the ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences. They have a non-use value, which means they have a non-quantifiable benefit. Their importance is a heavily debated topic in the scientific literature (e.g. Chan *et al.*, 2011), as it is very difficult to assign even a rough estimated value to these services. Cultural services often have an existence value; hence, their value is derived from the importance to cultures or societies. This means that nature can be a source of inspiration for peoples, science, cultures, and arts (de Groot *et al.*, 2002).

A substantial difference from the MA classification in the TEEB study is the use of habitat services instead of supporting services. Habitat services are defined as a subset of ecological processes that are essential to provide a habitat for migratory species, have a nursery function for native species, and protect gene pool diversity (TEEB, 2010). Habitat services are similar to cultural services in so far as that they have an existence value. Their main role is perhaps the protection of biodiversity and the enablement of vital underlying processes. Without those, an ecosystem would not be able to function properly. A lack of adequate habitats would inevitably threaten the rich biodiversity of South Africa, leading in turn to a decrease in the aforementioned ecosystem services. The importance of habitat services is therefore difficult to understate, although their value is not easily expressed in economic terms.

All ecosystem services also share an option and bequest value. Option values concern the possibility of a future use (e.g. the use of plants for medicinal purposes that have not been discovered yet), whereas bequest values deal with the use of services by future generations. *Table 2* provides an overview of the identified ecosystem services in the Langkloof.

4.2 Ecosystem Services Benefits

This section will address the benefits that humans can (directly or indirectly) derive from each of the ecosystem services in the Langkloof. The different stakeholders in and around the Langkloof area are not necessarily depending on the same services in a similar way. For example, services that are important for the local agriculture might be of lesser importance for other stakeholders.

Table 2. **Overview of the identified ecosystem services in the Langkloof. The description of services includes the various goods that the service provides, whereas the location of the service describes where that service is primarily provided at. The distinction in terms of location is made into farmland (transformed, cultivated land for agricultural or industrial purposes), natural vegetation (native vegetation such as forests, wetlands or fynbos that have been relatively untouched by humans), and IAPs (invasive alien plant species that are not native to the area).**

Ecosystem Service	*Description of Service*	*Location of Service*
Provisioning Services	**Provision of…**	**Primarily on…**
Raw Materials	lumber , fertilizer , fuel wood , wool , fodder , organic matter , skins, biofuels , plant oils	farmland natural vegetation
Genetic Resources	crop improvement genes , genetic vitality of cultivated or wild plants and animals	natural vegetation
Natural Medicines	medicinal plants , raw material for pharmaceutical use , potential source of medicinal resources	natural vegetation IAPs
Fresh Water	water for irrigation , drinking , domestic , natural , industrial purposes	natural vegetation
Food Products	agricultural crops , fish , game , wild food	farmland
Ornamental Resources	handicraft , decoration , souvenirs	natural vegetation IAPs
Regulating Services	**Regulation of…**	**Primarily on…**
Climate Regulation	atmospheric processes , weather patterns , micro-climate , greenhouse gases , temperature , precipitation	farmland natural vegetation
Air Quality Regulation	air pollutants , chemical composition of air , dust particles	farmland natural vegetation
Water Regulation Ability	runoff , water resources , water storage capacity	natural vegetation
Erosion Control	soil retention , land degradation	natural vegetation
Waste Treatment Capacity	waste removal , pollution	natural vegetation
Moderation of Extreme Events	landslides , flooding , fires , droughts , hailstorms , storms	natural vegetation
Pollination	Pollinator abundance , pollinator effectiveness , pollinator distribution	farmland natural vegetation
Biological Control	pests , animal- and plant diseases	natural vegetation
Maintenance of Nutrient Cycling and Soil Fertility	transport , storage , recycling , availability of nutrients	farmland

Cultural Services	Influence on…	Primarily on…
Educational Value	formal and informal education	farmland natural vegetation
Cultural Diversity and Social Relations	social diversity , accepted values and norms , interactions within society	natural vegetation
Knowledge Systems	types , use , transmission , retention , maintenance of knowledge	natural vegetation
Inspirational Value	art , folklore , architecture	natural vegetation
Aesthetic and Spiritual Value	aesthetic enjoyment , cultural- and religious heritage , sense of belonging , motivation	natural vegetation
Ecotourism and Recreational Value	tourism , leisure time , sports , hunting , fishing , hiking	farmland natural vegetation

Habitat Services	Provision of …	Primarily on…
Nursery Service	habitat suited for lifecycle of animals and plants	natural vegetation
Gene Pool Protection	genetic diversity , adaptation	farmland natural vegetation

An overview of the current state of each service is shown in *Table 3*. This information was collected through interviewing local stakeholders and by examining relevant scientific literature. As such, the table corresponds to the subset of ecosystem services and will provide the reader with an approximation of the current and future state of each service. It is important to keep in mind though that the information presented below is the result of the combined opinions of the various stakeholders and of an examination of the scientific literature. Hence, opinions between stakeholders and the scientific literature did not always agree. This made it difficult to confidently estimate the current and future state of each service. Thus, the information corresponding to each group of ecosystem services will be discussed in more detail in each chapter to ensure a better understanding of the importance and relevance of each service. For those services that not enough information was available, their condition was denoted as +/- . For all others, an approximation of their current state was made based on the gathered and available data.

4.2.1 Benefits and State of Provisioning Services

By definition, raw materials include all biomass that is used by species for a purpose other than food. Deciduous fruit farmers in the Langkloof often obtain fertilizers from local sources (DFF 2, 3). Fuel wood and wood for construction is another form of benefit that people in the Langkloof obtain from nature. However, the native fynbos vegetation is unsuited for such purposes. Thus, fuel wood and construction wood often stems from IAPs (Veerkamp, 2013), which were specifically introduced to South Africa for that reason. These trees are fast-growing, large, and have a high biomass content, which makes them highly effective fuel wood material.

Table 3. **Overview of current state of ecosystem services in the Langkloof and potential future changes to these services. Main driver of change denotes those activities that most heavily affect the state or future supply of an ecosystem service.**

Ecosystem Service	**Current Condition[1]**	**Likely future trends[2]**		**Main drivers of change in the Langkloof[3]**
Provisioning Services		Supply	Demand	
Raw Materials	+	↑	↑	Conversion of nature(+), timber extraction(+), population growth(-)
Genetic Resources	+/-	→	↑	Research(+), reduction of biodiversity(-), conversion of nature(-)
Natural Medicines	+/-	↓	→	Research(+), reduction of biodiversity(-), conversion of nature(-)
Fresh Water	--	↓	↑	Increased agriculture(-), population growth(-), soil erosion(-), conversion of nature(-), climate change(+/-)
Food Products	++	→	↑	Increased agriculture(+), population growth(-), climate change(-), conversion of nature(+), market (+/-)
Ornamental Resources	+/-	→	→	Conversion of nature(+/-)
Regulating Services				
Climate Regulation	+	→	↑	Conversion of nature(-), construction of fruit orchards(+)
Air Quality Regulation	+	↓	→	Conversion of nature(-), increased agriculture(-)
Water Regulation Ability	+/-	→	↑	Conversion of nature(-), soil erosion(-), pollution(-), new infrastructure(+)
Erosion Control	-	↓	↑	Conversion of nature(-), increased agriculture(-), climate change(-)
Waste Treatment Capacity	+	→	↑	Conversion of nature(-), reduction of biodiversity(-), pollution(-), new infrastructure(+)
Moderation of extreme events	-	↓	↑	Conversion of nature(-), climate change(-), new infrastructure(+),
Pollination	+	→	↑	Conversion of nature(-), increased agriculture(-), import of beehives(+)
Biological Control	+	→	↑	Conversion of nature(-), reduction of biodiversity(-), research(+), chemicals(+), climate change(+/-)

Maintenance of Nutrient Cycling and Soil Fertility	+/-	↓	↑	Conversion of nature(-), climate change(-), increased agriculture(-), reduction of biodiversity(-)
Cultural Services				
Educational Value	+/-	↓	→	Conversion of nature(-), reduction of biodiversity(-), acknowledgement of nature(+)
Cultural Diversity and Social Relations	+	→	→	Population growth(+/-)
Knowledge Systems	+	→	→	Acknowledgement of nature(+)
Inspirational Value	+/-	↓	→	Conversion of nature(-), reduction of biodiversity(-)
Aesthetic and Spiritual Value	+/-	↓	→	Conversion of nature(-), reduction of biodiversity(-)
Ecotourism and Recreational Value	-	↑	↑	New developments(+), new infrastructure(+)
Habitat Services				
Nursery Service	+	↓	→	Conversion of nature(-), increased agriculture(-), population growth(-), tourism(-)
Gene Pool Protection	+/-	↓	↑	Reduction of biodiversity(-)

1 = ++ very good , + good , +/- not enough data available , - bad , -- very bad

2 = ↑ increasing , → stable , ↓ decreasing

3 = + positive impact , +/- can be both positive and negative , - negative impact

Fuel wood is still widely used in the Langkloof due to issues with electricity or the absence of it in informal housings (GOV 2). Wood for constructional purposes is also often used in the area, especially in the agricultural sector, where fruit crates and other farming utensils are often made out of wood (DFF 2, 3, 5, 6, 7, 9). Some farmers also use wood for mulching purposes. The organic matter is thereby broken down into smaller pieces and then spread on cultivated soil. Once this organic matter decomposes, it adds nutrients to the soil and enhances soil fertility and the water retention potential. Almost all interviewed farmers stated that they use mulch. Moreover, some farmers also have access to a wood chipper, and in that case can use black wattles (*A. mearnsii*) and other IAPs to create mulch. Fodder is also used for the local livestock agriculture, although livestock farming only plays a minor role compared to the much larger deciduous fruit industry in the Langkloof. Livestock farming in the Langkloof is situated mainly on the mountainous slopes around the valley and within the Renosterveld vegetation, as the dominant fynbos vegetation has a low agricultural potential (Veerkamp, 2013). Livestock farmers frequently burn their grass fields and cultivate the land with oats and wheat in order to raise the grazing potential of the land. The potential of plant oils and biofuels is not very high in the Langkloof, and as such, not used to a large extent.

Food products refer to the biomass of plants and animals which can be converted to energy and nutrition, and thus sustains humans (and living organisms). Local game used to be a primary source of food for settlers in the past, although with the introduction of fruits and vegetables, the Langkloof has shifted to primarily cultivating those, and has drifted away from hunting and eating wild animals. Meat is largely imported from other regions and countries, thus only a small amount is from local sources. Wild harvesting of plants or berries (e.g. fruits of the prickly pears for jam), or the hunting of animals, is rare and mainly occurs along the mountainous slopes of the valley, as there are few edible plant species or wild animals within the valley itself (Veerkamp, 2013). Hence, food products in the Langkloof mainly stem from its large deciduous agricultural sector that provides fruit not only for the people in the Langkloof, but also for other regions in South Africa and many other countries in the world. The majority of those fruits are apples and pears, which are ideally suited to the climate in the Langkloof. Many interviewed farmers highlighted the high quality of the fruit. Recently there has also been an increase in the cultivation of honeybush for tea in the Langkloof and the adjoining Kromme area. Honeybush is a rising export product of the area due to the increased demands for it internationally. In order to facilitate and enable these large-scale agricultural activities, a vast amount of the landscape within the Langkloof valley has been converted from natural vegetation to cultivated lands. Many orchards have been planted throughout the valley in the past, and new orchards are still being planted every year.

The provision of genetic resources refers to the ability of animals and plants to self-maintain themselves over a period of generations. Of primary importance perhaps in the Langkloof is at first glance the genetic diversity in soil organisms. These help to create and maintain a productive soil and facilitate agricultural activities in the valley.

The provision of water is perhaps the most important ecosystem service in the Langkloof, and its importance has been stressed in all interviews. As stated previously, the mountains around the valley act as a water trap, and the local fynbos vegetation help to filter rain water and provide fresh water. The Kouga catchment provides an estimated amount of 148.2 million m^3 of water per year, which is being used almost entirely. Only a very small amount (less than 2 %) flows out to the ocean (Blignaut *et al.*, 2009). All stakeholders in the Langkloof highly depend on water. Farmers need water primarily for the irrigation of their orchards, but also for other purposes, such as drinking water for employees and for sanitation purposes. The municipality has a responsibility to provide adequate drinking water for the settlements and for domestic purposes. Also, the water from the Kouga catchment supplies downstream regions such as the Gamtoos valley and the Nelson Mandela Bay Metropolitan Region. It is therefore not surprising, that many of the conflicts between stakeholders revolve around water issues, and that water security is one of the most important concerns for the future. Apart from its human uses, water is also necessary for the living organisms in the valley, and thus is essential for the functioning of the ecosystem.

Natural medicines consist of plants or raw plant material that are either used in traditional medicines, or have a use in pharmaceutical research, in order to improve or restore the health of humans or other living organisms. South Africa, and especially the Kouga catchment, of which the Langkloof is a part of, has a rich biodiversity, and Thring and Weitz (2006) estimate that approximately 3,000 different plant species are used in traditional medicines throughout South Africa, with 38 indigenous plant species being commercially used in medicines (Van Wyk, 2008). The local honeybush tea is used within the area and also exported internationally for its health-improving purposes. Despite this, the use of plants and plant material for medicinal purposes is small in the Langkloof, and mainly only carried out by the black communities (Veerkamp, 2013). Fynbos is also used for making herbs, although not on a large scale or for pharmaceutical purposes.

Ornamental resources are those products obtained from animals or plants that are used for landscaping or ornamental purposes. This can include the skins or shells as animals, or leaves of plants or whole plants. Even today many people in the Langkloof use the local fynbos vegetation for ornamental purposes (Turpie *et al.*, 2003).

Undoubtedly, the two most important provisioning services in the Langkloof are the provision of fresh water and the various food products. Water is a limiting resource in the Langkloof, and is especially important for the produce of fruits, which is the main economic activity. As shown in *Table 3*, the supply of fresh water is likely to decline in the future, mainly due to increased demands of people and agriculture. However, the effects of climate change could potentially alleviate the situation, as rainfall could increase in the area. At the same time however, climate change can also increase the frequency of extreme events or change climatic conditions in a way that would reduce the production of foods. While the conversion of nature into cultivated land will benefit some services such as the provision of raw materials and food, it will likely reduce the supply of fresh water, genetic resources and natural medicines. Unsustainable management practices, climatic changes and overuse are perhaps the major threats to provisioning services in the Langkloof, especially when considering the conflicts between the two largest users: the municipality and the fruit farmers.

4.2.2 Benefits and State of Regulating Services

Ecosystems have the ability to influence the climate on a local, national and global scale. Vegetation can help to retain, manage and sustain water in an area, and plants, through photosynthesis, remove greenhouse gases such as CO_2 from the atmosphere. Ecosystems regulate the local climate to a large extent and help in providing relatively stable and foreseeable conditions. Due to the relatively small size of the Langkloof itself, its climatic influence is mainly limited to a local scale. Land-use changes by humans and the accompanied transformation of natural vegetation to cultivated land have an influence on the amount of precipitation and on the temperature in the area, and have contributed to shape the valley’s microclimate. The prevailing circulation patterns and the topography around the valley provide the Langkloof with vital water through precipitation. The local environmental conditions also provide freezing days in winter, which are needed for the growing of apples and pears (Luedeling, 2012). Furthermore, the high number of orchard trees in the area and the still large areas of natural vegetation in the Langkloof and the Kouga catchment help in removing GHG from the atmosphere and thus contribute to climate regulation on a larger scale. Nevertheless, there is a potential for carbon sequestration in the valley, and various stakeholders have identified this potential and are currently considering becoming active in this regard (Expert (EXP) 2). The natural fynbos vegetation has a high carbon storage potential and could therefore play an important role in the storing of carbon from the atmosphere (Cowling *et al.*, 2004).

Also, natural vegetation in an ecosystem helps to maintain and regulate the composition of the air through the removal or release of chemical substances from and to the atmosphere. Agriculture in the Langkloof not only depends on fertile soils and ample water, but the quality of the air also enhances crop yields, as well as improves the livelihood of the local population. Many interviewees have stressed the healthiness and fresh air of the Langkloof, which is owed mainly to the natural (and cultivated) vegetation in and around the valley, although the sparse population and low amount of road traffic contributes to this as well. The vegetation also helps in taking up chemical pollutants such as ammonia and sulphate, and removes dust particles from human pollution or after fires, and thus reduces air pollution.

Through land cover, topography, soil properties and hydrological conditions, ecosystems have the ability to regulate the spatial and temporal distribution of water within an ecosystem. Distribution and management of the available water resources by the ecosystem through the influence of rivers, wetlands and soils, is essential for plant and animal species in the area, but is also indispensable for the agricultural activities and the livelihoods of peoples in the Langkloof. However, the extensive conversion of natural vegetation and wetlands into cultivated land and settlements have reduced the area's water storage ability. Surface water runoff has increased and floods have become a greater threat due to the removal of vegetation. Especially on the mountainous slopes, the rich fynbos vegetation is playing a key role in the creation of river and water channels that sustain not only the Langkloof, but also the whole Kouga catchment and its downstream beneficiaries, due to its large capacity to uptake water from the air and the soil. Le Maitre *et al.* (2007), have estimated the water runoff in fynbos dominated vegetation to be between 35 % and 55 % of the total precipitation. As such, the conversion of natural vegetation into agricultural land, and the invasion of IAPs pose a significant threat to the availability and proper regulation of water.

Oftentimes, one of the main consequences of land degradation and transformation is extensive soil erosion. Soil erosion leads to the loss of nutrient-rich upper soil layers, which limits the productive ability of the soil. This has an impact on the local agriculture and the stability of the ecosystem. The native fynbos vegetation is well-suited to prevent soil erosion. Its vast vegetation cover largely absorbs the impacts of rain drops and thus reduces the so-called splash erosion, where the impact of rain drops on soil ejects a small amount of soil particles, which can then be transported away by wind and water once the soil is saturated with water. Additionally, the strong roots of the fynbos plants help stabilize the soil and limit the effect of erosion (Cowling, 1992). However, in the Langkloof, soil erosion is becoming an increasing worry for many stakeholders (EXP 2). During periods of heavy rainfall, many soils start to erode, especially near slopes or streets. This causes infrastructural damages, and in some cases, the municipality is struggling to keep up road and other infrastructure repairs originating from soil erosion (see *Picture 2*) (GOV 2). The rapid spreading of IAPs further strengthens soil erosion, as the pine trees and *A. mearnsii* replace native vegetation. Forest vegetation types that consist of tall and strong trees also have a higher surface water runoff than fynbos (Scott, 1993), resulting in larger volumes of soil erosion. In other instances, efforts to clear the area of IAPs have resulted in the cut-offs of black wattles (*A. mearnsii*) and other IAPs to be left behind in the river bed. Consequently, the river becomes more clogged, and during periods of heavy rainfall, those rivers are more prone to overflow, leading to more severe and wide-spread soil erosion.

Picture 2. **Soil erosion inhibiting road safety. Photo Source: Author**

Ecosystems have a capacity to decompose organic wastes that have been introduced naturally or unnaturally to an environmental system. Living organisms and the vegetation itself can filter, assimilate and detoxify harmful pollutants and decompose them. As such, the ecosystem is able to regulate the water quality and prevent a spreading of pollutants. In the Langkloof, it is an important service as it supplies clean water throughout the valley. Many interviewees have commented on the high quality of the water, stating that they do not purify or treat the water that they use for irrigation.

Another important regulating service that ecosystems carry out is the moderation of extreme events. This moderation is achieved by ecosystems in two ways. Firstly, ecosystems regulate the atmospheric conditions and stabilize the climate, thus decreasing the risk of extreme events. Secondly, ecosystems are able to buffer the impacts of extreme natural events. They do so by absorbing water from heavy rain, stabilizing the soil to prevent landslides, or by limiting the effects of droughts for example. The moderation of extreme events is especially important in the Langkloof area, where natural disasters are frequent and their impacts can have devastating effects on the local agriculture, the general infrastructure and the livelihood of citizens. In the recent past, the Langkloof has been exposed to a number of natural disasters, such as repeated floods, severe droughts, devastating hailstorms and widespread fires. The degradation of natural landscape that has been going on in the Langkloof for decades has limited the ability of the ecosystem to moderate these events. Wetlands that are able to absorb water during heavy rainfall have been converted, river channels have been straightened and are thus more prone to overflow, and natural vegetation has decreased and is thus not able to stabilize soils or take up as much water as before. However, despite this, the ecosystems in the Langkloof are still able to mitigate the effects of natural disasters. The rugged mountainous landscape of the Kouga and Tsitsikamma Mountains consists of hard rock formations, which are very resistant towards soil erosion. Furthermore, the sandy soils in and around the valley have a large capacity to uptake water, and the disappearance and controlled burning of native vegetation actually reduces the risk of a spreading of wild fires.

Pollination is a process whereby plants transfer pollen grains (male gametes) to other plants of the same species, and where these pollen grains are then able to fertilize the ovules (female gametes). Without pollination, many plant species nowadays would face extinction (de Groot *et al.*, 2002), and insect populations would be much lower. Pollination raises the production of plants and is thus essential for the development of fruits and vegetables. The large agricultural sector in the Langkloof is heavily dependent on the existence of natural pollinators. Bees perform the largest share and ensure that crops are pollinated, which in turn results in a higher crop yield. All interviewed farmers were aware of the importance of pollination, and the majority also hired bee-hives from beekeepers to ensure an adequate pollination of their trees. Despite the added costs of hiring and moving the hives, this is an effective measure. By planting beehives in their orchards, farmers increase the probability of successful pollination, and are thus able to harvest more fruit. During the off-season for fruit production, beekeepers are also able to use their bees for the production and selling of honey, which provides them with additional income. Additionally, many farmers now spray less harmful chemicals, and sometimes spray at night, to limit the impact on pollinators. Another benefit of pollination is the retention of high biodiversity in the area. Without pollination, many plant species could not survive. This would not only reduce biodiversity, but in turn also weaken other ecosystem services.

Biological control is a service that is similar in its function to the ability to treat and manage waste materials. The ecosystem is able to regulate animal and plant populations and is able to prevent the spreading of pests or diseases through natural and biological control mechanisms. Predation, parasitism, herbivory and competition between species are forms of biological control that help in creating a stable balance between species in an ecosystem. This balance is further supported by natural control factors such as the temperature, humidity, topography, habitat size and availability of water, all attributes that ecosystems are able to provide and maintain. Biological control ensures a reliable supply of many provisioning services and prevents the spread of pests or disease-carrying animals. Reducing the natural vegetation, as has happened in the Langkloof, also negatively affects the ecosystems' ability to maintain an effective biological control, as there is much less biodiversity in a cultivated landscape. As such, there are a number of diseases and pests that local stakeholders have to deal with. The municipality is mainly concerned with providing clean drinking water and medicines for citizens, whereas the farmers worry for their crop yield due to the occurrence of moths and other crop-harming organisms. This in turn requires additional efforts in terms of time and financial capital, and also requires fruit farmers to use more pesticides.

The role of ecosystems in the transport, storage and recycling of nutrients is invaluable to humans. Nutrients are essential for life to flourish, and without them no agricultural production could have started in the Langkloof. The maintenance of the nutrient cycling refers to the ability of the ecosystem to maintain a balance of nutrients, where the right amount of needed nutrients is at the right place at the right time. This balance is achieved through a cycling of nutrients through organisms and the environment they live in. The most important nutrients are Phosphorous (P) and Nitrogen (N), and they exist in a balance between each other that has been developed over a long time period. The soils in the Langkloof however, are comparatively rich in nutrients when compared to the soils of other regions in the Eastern Cape or South Africa.

The single largest threat to regulating services is the conversion of nature into cultivated and farm land. By degrading or removing natural vegetation, the ecosystem's ability to regulate climate, water and nutrients is reduced, and its ability to mitigate soil erosion or extreme weather events declines. This situation could be further exacerbated by the influences of climate change, a growth in population or increased pollution in the future. Human interference with the environment and the adding of chemical substances into soil and aquatic systems has a negative impact on the ability of ecosystems to maintain its environmental balance.

4.2.3 Benefits and State of Cultural Services

Nature presents humans with an almost inexhaustible variety of processes and functions. Studying those processes have allowed humans to adapt to their surroundings and invent new technologies. The nature in the Langkloof also provides possibilities for scientific research, as the valley is currently in a sensitive balance between striving for economic gains and sustainably managing its natural resources. Research in the Langkloof and the Kouga catchment has increased in recent years, as the regions importance as an economic hub and ecological catchment are becoming increasingly important in national policies as well. There are still many environmental research opportunities in the Langkloof.

The apparent diversity within an ecosystem has also influenced the diversity of cultures. Living with and depending on their environment has had a large impact on the range of accepted values and social practices within a society. In a somewhat isolated environment like the Langkloof, as it is surrounded by mountainsides, a group mentality and sense of belonging has formed amongst its inhabitants. The valley also has a long tradition of fruit farming, and as such, knowledge on how to farm in its environment has been passed on through generations already, and certain measures have become common-practice. For example, efforts to limit human's effects on their environment are wide-spread and accepted in the valley. There is also a strong belonging to the Boer-culture amongst many of the white people, especially amongst those of which families have been living in the Langkloof for many generations. This strengthens ties between like-minded people and provides a sense of comfort and belonging.

Observing processes in nature helps humans in understanding their surroundings, and enables them to be more efficient in their approaches when interacting with nature. The variety of ecosystems thus provides humans with knowledge systems such as education, social learning, and understanding. Nature can also serve to inspire humans. By copying aspects of nature, humans have been able to produce and improve technologies. It also allowed humans to produce certain styles of art (e.g. painting of animals or landscapes), architecture and folklore. The Langkloof is part of the Kouga catchment which belongs to the Baviaanskloof Mega Reserve (BMR). Recognizing its natural and cultural importance, the BMR has been adopted as a World Heritage site by UNESCO in 2004.

Aesthetic values refer to the appreciation of nature by humans (de Groot *et al.*, 2002). Ecosystems can have an influence on how people perceive their aesthetic values, and landscapes have long been a popular motif for paintings and pictures. There is a consensus amongst the people in the Langkloof that they have a beautiful landscape, which adds enjoyment and contentment to people's daily lives. While there are no native tribes living in the area that have attached a spiritual value to their environment in the Langkloof itself, there are old rock paintings to be found in the nearby Kouga Mountains, which speak of the traditions of the San people (Veerkamp, 2013). These painting furthermore are of a cultural heritage value, and present a point of interest for tourists.

Nature also provides a multitude of recreational possibilities for humans. Many people use nature during their leisure time to hike, mountain bike, meditate, paint, fish, climb, or simply relax. The benefit that humans receive from those activities is personal enjoyment, fitness and refreshment. Although the Garden Route to the South is close to the Langkloof and attracts more tourists, there are still possibilities for enjoyment in the valley itself. Some farmers possess guest houses which they rent out to tourists (DFF 8), and there are a number of hotels and resting places within the Langkloof. The valley also contains the large 'Kouga wildernis', which starts just north of the settlement of Joubertina. This is a popular place for tourists and local people to hike and mountain bike.

Again, the conversion of nature in the Langkloof has primarily negative effects on the provision of cultural services. Increased agricultural production and transformation of land reduce the attractiveness of the landscape and compromise the environmental conditions that are essential for cultural services. However, new infrastructure and sustainable development plans could very well expand tourism in the area. Especially in this area, nature-based solutions have a potential for a win-win situation. Revenues from eco-tourism could be used to protect and sustain the ecosystem services in the area.

4.2.4 Benefits and State of Habitat Services

Habitats provide a living organism with everything it needs to survive. This includes food, water, shelter, protection, and adequate climatic conditions. Each ecosystem thereby has its own habitat, and provides living conditions for different species. Habitat services are also benefitting migratory species as a temporary resting or living place. Furthermore, habitat services also protect and facilitate the genetic diversity between species. This genetic diversity ensures that species of living organisms are well-adapted to their surroundings and are able to deal with disturbances or alterations. The Langkloof valley is part of the Kouga catchment, which belongs to the Cape Floristic Region. The fynbos vegetation, which is also dominant in the Langkloof, is characterised by its high biodiversity. As such, the CFR is one of the major biodiversity hotspots in the world. The Kouga Mountains to the north of the catchment provide a natural habitat for many species, which allows a large diversity of the gene pool (de Groot *et al.*, 2010). The Formosa Nature Reserve within the Langkloof is a protected area and thus limits the amount of interaction between humans and other living organisms.

Again, the main threat to the provision of these services in the Langkloof is the rapid conversion of natural vegetation. A reduction of habitat leads to a loss of species and a destabilization of the sensitive ecological balance in the ecosystems in the study area. A growth in population and an expanse of agricultural activities would further reduce the habitat and diversity of many important species.

5 Climate Change Analysis

Climate change is one of the most pressing environmental concerns today. The issue of climate change and the consequences thereof has become and increasing topic in scientific research, political debates, amongst the media, and for decision-makers in many sectors. Researches and efforts of the Intergovernmental Panel on Climate Change (IPCC) have helped in highlighting the importance of climate change all around the world and have made it a controversial and much talked-about topic. The latest IPCC report, the 5th Assessment Report, was released in late 2013 and early 2014, and has once again concluded that climate change is an ongoing process that will more than likely lead to higher global temperatures and a significant change in rainfall patterns, amongst many other impacts (IPCC, 2014). The 10 hottest years ever recorded (since 1880), have all fallen within the last 16 years, with 7 of those taking place in the last decade. Furthermore, the current year, 2015, is on course to be the warmest year ever recorded, with a global temperature anomaly of 0.70°C when compared to the 1901-2000 mean (*Table 4*).

***Table 4*. Ten warmest years on record (°C anomaly from 1901-2000 mean for a 12-month period, starting in January)**

Year	Global	Land	Ocean
	Temperature anomaly		
2015	0.70	1.02	0.58
2006	0.64	1.01	0.49
2011	0.64	1.03	0.49
1999	0.63	0.97	0.50
2007	0.63	1.01	0.49
2014	0.63	1.01	0.49
2003	0.61	0.92	0.49
2004	0.61	0.85	0.52
2010	0.60	0.85	0.51
2013	0.59	0.92	0.46

Source: NCDC (National Climatic Data Center) 2015. http://www.ncdc.noaa.gov/cag/time-series/global

Moreover, the warming trend is accelerating rapidly. The linear warming trend of the past 50 years (+0.15°C per decade) is more than double that of the 50 years previously (+0.06°C per decade) (NCDC, 2015).

The 5th IPCC assessment report stated once more with a very high likeliness that humans have had a considerable impact on climate change through the burning of fossil fuels and other activities, such as the burning of biomass, the removal of large patches of natural vegetation, the expansion of livestock agriculture, cement manufacture, amongst others. These activities lead to a strengthening of the greenhouse effect either by adding greenhouse gases such as methane or CO_2 to the atmosphere, or by altering the ability of ecosystems to regulate and balance the climate system. Humans have thus contributed a large share towards the ongoing climate change, and a slowing down in those harmful activities is hardly discernible (IPCC 5th Assessment Report, 2014). This will almost certainly have large effects on a variety of human industries and many people's livelihoods in the future.

The agricultural sector is especially vulnerable to changes in the climate, as crops very often have specific climatic requirements in order to yield a desired amount of harvest. As such, the agricultural sector faces many challenges in the future related to climate change. Risks include a reduction of rainfall, a shift in rainy or dry seasons, an increase of temperature, a change of soil properties, and a change in frost units, amongst others (Benhin, 2008; Gbetibouo and Hassan, 2005). Hence, climate change presents a threat to agricultural productivity, although there are also windows of opportunity for agriculture in many regions of the world. Likewise, human well-being is also likely to be impacted negatively by climate change. With a warming of temperatures, diseases limited to tropical regions such as malaria might spread more, and impacts on water and food resources can cause famines and shortages of resources in many regions. A change in climate can also disrupt the global circulation pattern, resulting in more erratic weather conditions. This increases the chance of extreme natural events, further threatening human health and industrial productivity. Moreover, climate change is of heightened importance in already water-stressed countries such as South Africa or the majority of the African continent, due to the fact that global warming will increase evaporation, and in many cases reduce rainfall. The South African government is therefore not surprisingly investing resources and efforts into many researches that deal with predictions and impacts of climate change (DEA 2013a and b , DEADP, 2008). Currently there is an assessment carried out by the African Climate and Development Initiative (ACDI) and SmartAgri at the behest of the Department of Agriculture with the aim of providing a status quo review of climate change and its impacts on the agricultural sector in the Western Cape Province (DA and DEADP, 2014). A similar project has been undertaken by the Department of Economic Development and Environmental Affairs in 2011, which amassed response strategies to climate change in the Eastern Cape. A research by Johnston *et al.* (2011) also provided climate projections and possible impacts arising from climate change in the Eastern Cape.

5.1 Past Trends in Climate

Most common amongst climate data, and perhaps also most suggestive in terms of climatic trends, are records on average temperature and rainfall from the past. Due to the large variety of climates in South Africa, it is necessary to consider only regional data for this research, as national temperature and precipitation records would not adequately represent the Langkloof. Thus, only data concerning the Eastern Cape or the Langkloof valley itself were considered for this analysis.

The Climate System Analysis Group (CSAG) of the University of Cape Town possesses data on average monthly rainfall and temperatures from the Langkloof valley, including information on months of heavy rain or days of extreme temperatures. Their datasets are limited to the years between 1966 and 1988. Additionally, Johnston *et al.* (2011) amassed and analysed rainfall and temperature data from nine weather stations in the Eastern Cape region (see *Figure 4*). Due to a lack of reliable historic data, their records were limited to the period of 1979 to 2000, which presents a relatively short time frame. Nevertheless, this interval was chosen due to a greater reliability of the data, and Johnston *et al.* were confident in the climatic significance of the data.

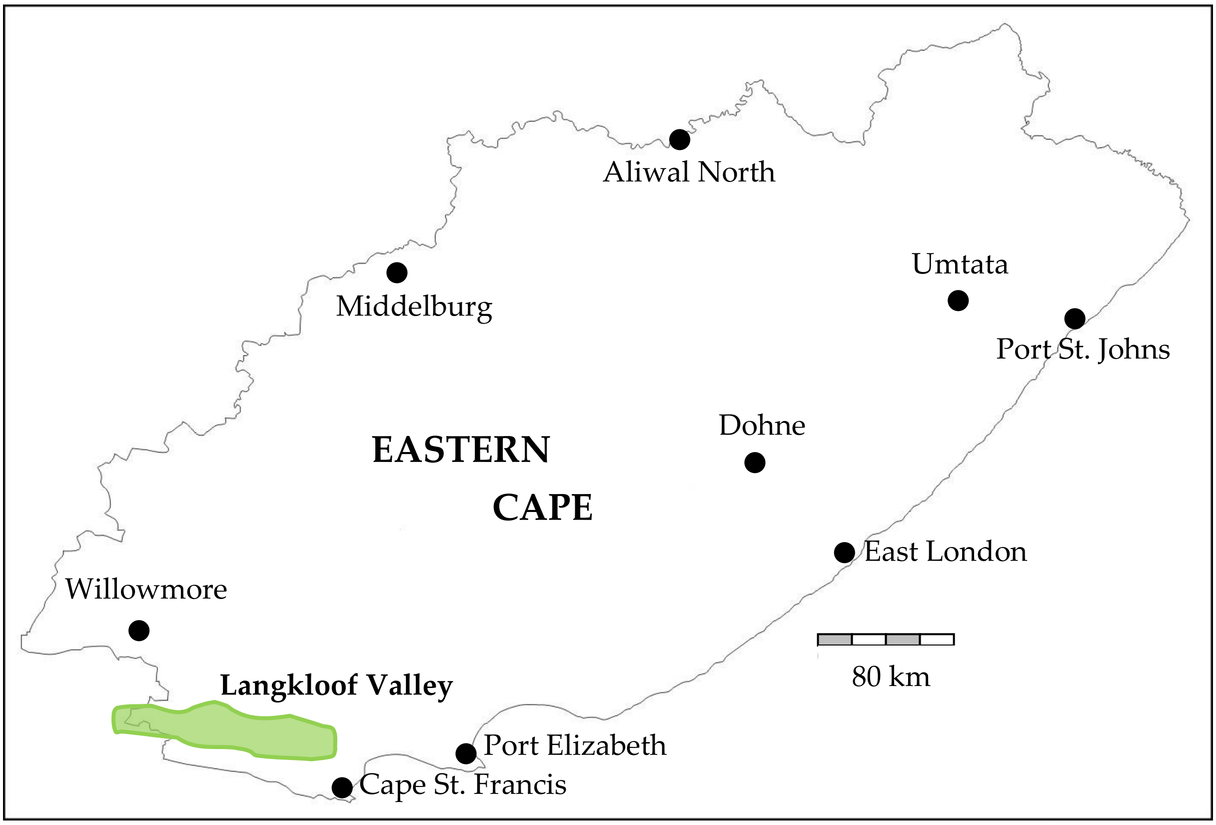


***Figure 4*. Overview of the nine weather stations that were analysed by Johnston *et al.* (2011), plus an indication of the location of the Langkloof valley.**

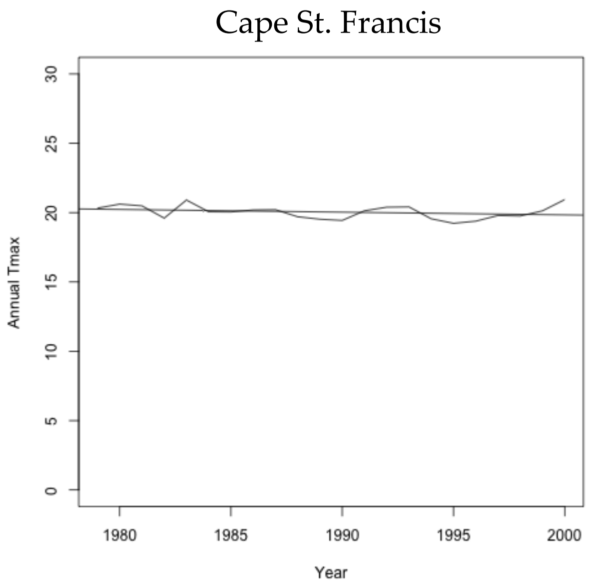
5.1.1 Temperature

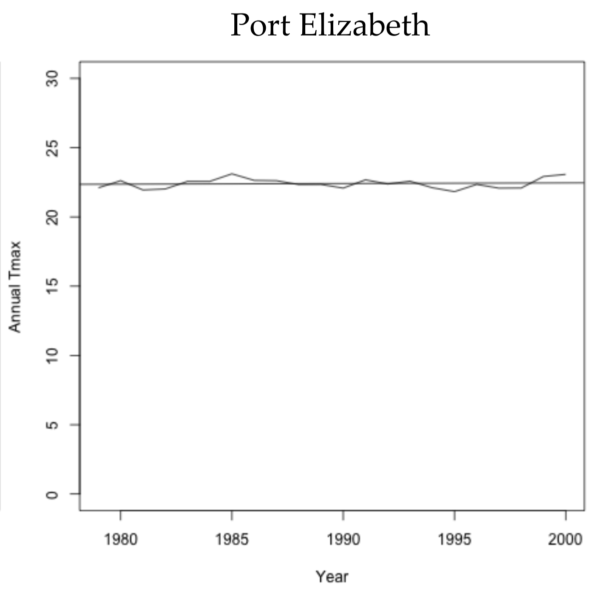
Temperature is a very important factor when looking at climate data. It has an influence on the availability of water, the healthiness of living species, and the properties of the soil. Impacts of a temperature rise could heavily affect agricultural production, but could also have impacts on human health and water availability. Monthly averages of the daily maximum temperatures provide information on the seasonal cycles of a region (Johnston *et al.*, 2011) and also give a good indication of a prevailing temperature trend. However, it is always important to also consider data that records minimum temperatures. There can be variations in minimum temperatures that are different from changes in the maximum temperature. Minimum temperatures are especially important for the agricultural sector, as many fruits require a certain amount of frost units for an optimal harvest (Luedeling, 2012).

A rise in minimum temperature could thus have devastating consequences for popular fruit varieties in the Langkloof (Benhin, 2006; Calzadilla *et al.*, 2014).

Temperature records from the Eastern Cape and the Langkloof stem from datasets of the CSAG of the University of Cape Town, and are also available from the nine weather stations that Johnston *et al.* (2011) examined. Average annual maximum temperatures from the nine weather stations in the Eastern Cape depict no clear trend, and have stayed more or less the same in the nine investigated stations between 1979 and 2000. Average annual maximum temperatures are around 21 to 23°C in the three stations closest to the Langkloof between 1979 and 2000 (see *Figure 5*).

The CSAG dataset on average annual maximum temperatures in the Langkloof however presents a slight trend towards an increase in temperature between 1966 and 1987, as shown in *Figure 6*.





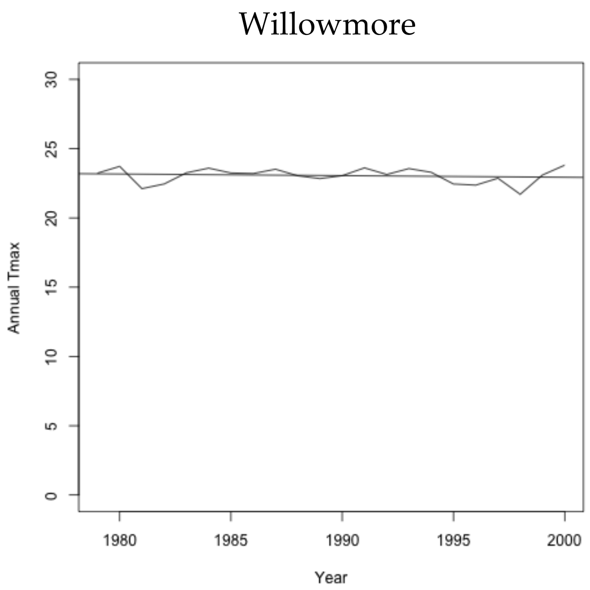


***Figure 5*. Average annual Tmax trend of three weather stations close to the Langkloof valley (1979 to 2000). Source: Johnston *et al.*, 2011**

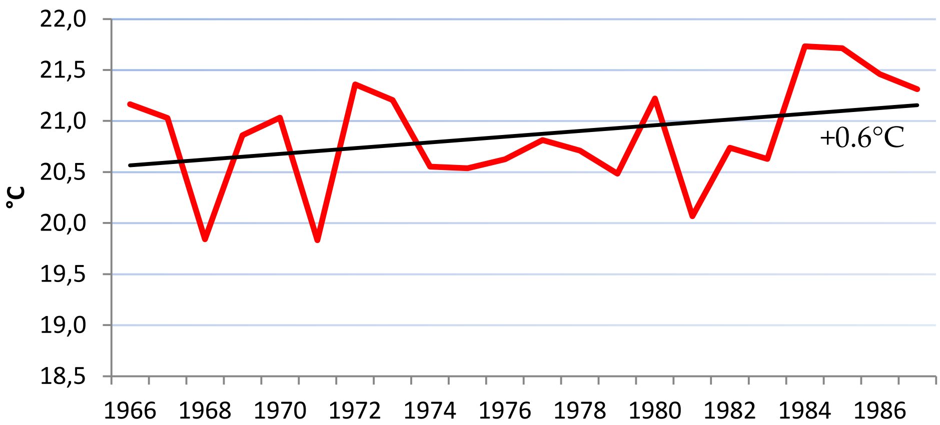
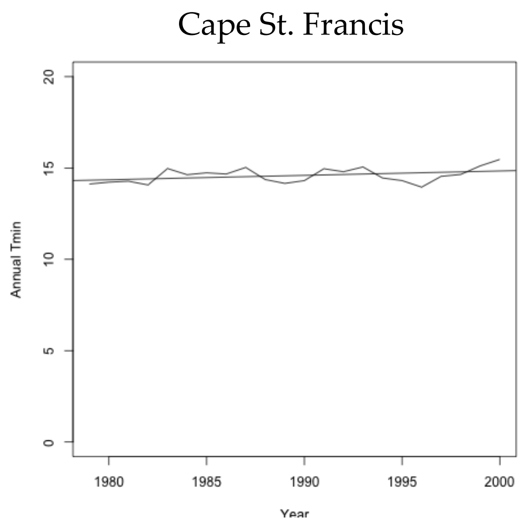
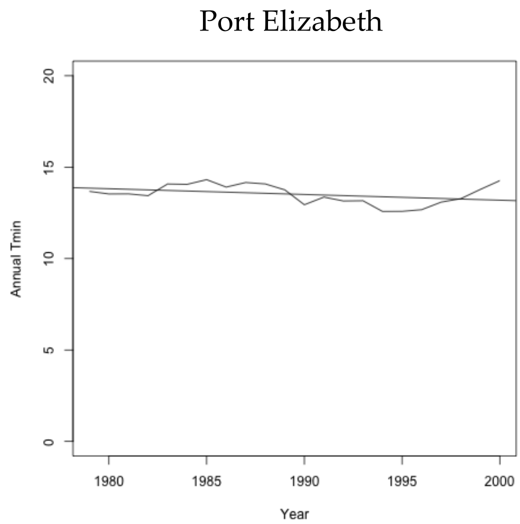


Figure 6. **Average annual Tmax temperature trend in the Langkloof for the time period of 1966 to 1987. Throughout the dataset, average Tmax temperatures rose by 0.6°C. Data Source: CSAG, 2015.**

Despite the existing inter-annual variation, average maximum temperatures in the time period between 1966 and 1987 have increased from approximately 20.55 to 21.15°C. This represents an increase of 0.6°C within those 22 years.

In terms of minimum temperatures, all nine weather stations in the Eastern Cape region once again lack a clear trend. While five of the nine stations depict a minimal increase in annual average minimum temperatures, the three stations closest to the Langkloof lack such a trend (*Figure 7*).





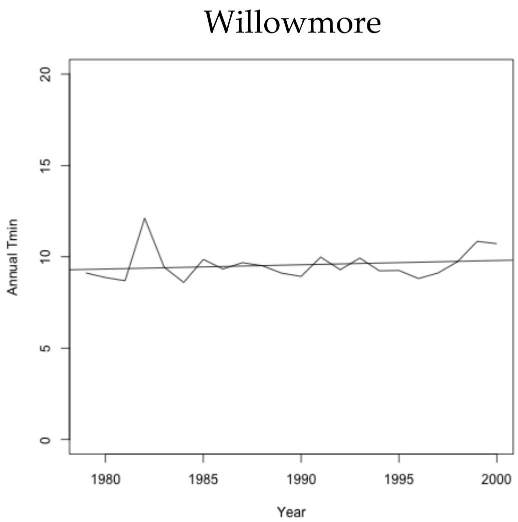


Figure 7. **Average annual Tmin trend of three weather stations close to the Langkloof (1979 to 2000). Source: Johnston *et al.*, 2011**

The CSAG dataset for the Langkloof region itself paints a slightly different picture again (*Figure 8*). There seems to be a trend in increasing average annual minimum temperatures in the time period of 1966 to 1987. Overall, minimum temperatures increase from around 9.7°C to 10.5°C, which is an increase of 0.8°C in 22 years

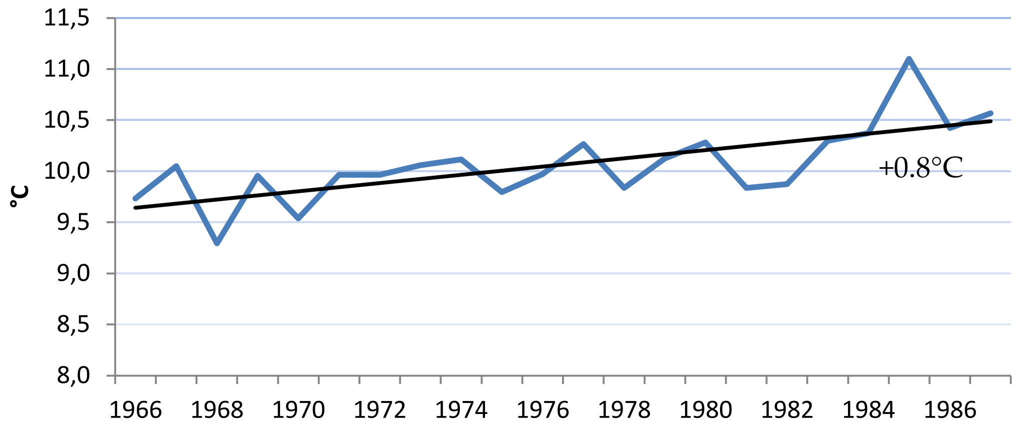


***Figure 8*. Average annual Tmin temperature trend in the Langkloof for the time period of 1966 to 1987. Throughout the dataset, average Tmin temperatures rose by 0.6°C. Data Source: CSAG, 2015.**

5.1.2 Rainfall

A possible influence on the amount of rainfall is one of the largest concerns attached to the ongoing climate change, and could also have severe repercussions for agriculture and human livelihoods.

Of the nine investigated stations examined by Johnston *et al.* (2011) however, none showed a significant change in the amount of rainfall between 1979 and 2000. It is worth mentioning that four stations exhibited a slight increase in annual rainfall, despite it not being very large or statistically significant. These four stations are all situated to the very east of the Eastern Cape, near the eastern coast, and are thus furthest away from the Langkloof valley. Differences in the amount of rainfall were also large, confirming the heterogeneity of South Africa in terms of climate, and making it difficult to draw conclusions for the Langkloof. Average annual rainfall in the stations closest to the Langkloof was around 230 mm (Willowmore), 560 mm (Port Elizabeth), and 630 mm (Cape St. Francis). The two latter stations are however located at the coast, and are thus prone to receiving more rainfall than inland regions such as Willowmore or the Langkloof.

A look at the data from the University of Cape Town reveals similar rainfall trends for the Langkloof in the recent past. *Figure 9* shows that there is no clear trend in terms of rainfall in the selected time period. Average annual rainfall in this time-span was 639 mm in the Langkloof, which is above the estimated value of 500 – 550 mm from the Department of Water Affairs (DWAF, 2009). There may be a slight increase in overall annual rainfall, although it does not appear to be statistically significant. Furthermore, the low amount of documented years, the large variation between years, and the omission of the years 1983 – 1986 reduce the significance of this dataset.

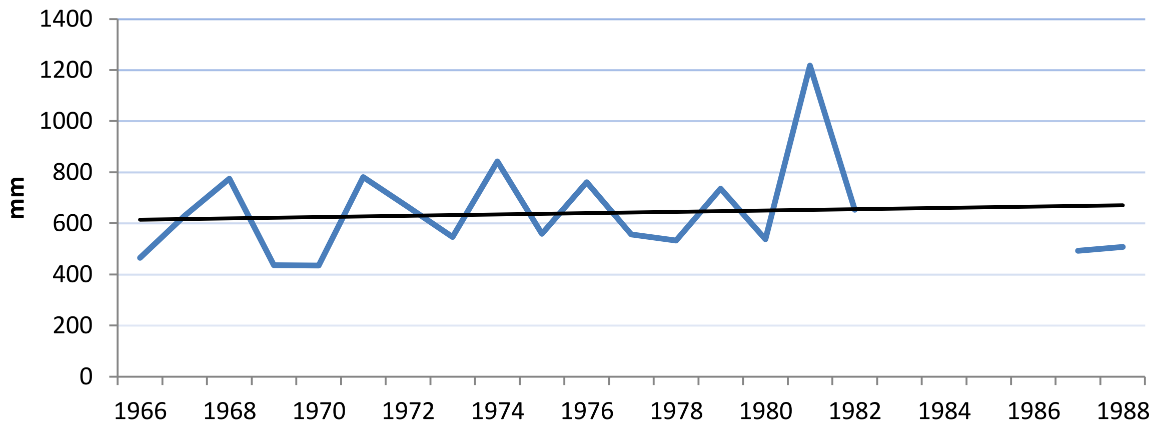


Figure 9. **Average annual rainfall trend in the Langkloof for the time period of 1966 to 1987. Data Source: CSAG, 2015.**

Private recordings of total amount of rainfall in Joubertina were also available (Sam van der Merwe, 2014, personal communication), and provide additional information. This dataset provides monthly observations from 1937 to 2014 (*Figure 10*).

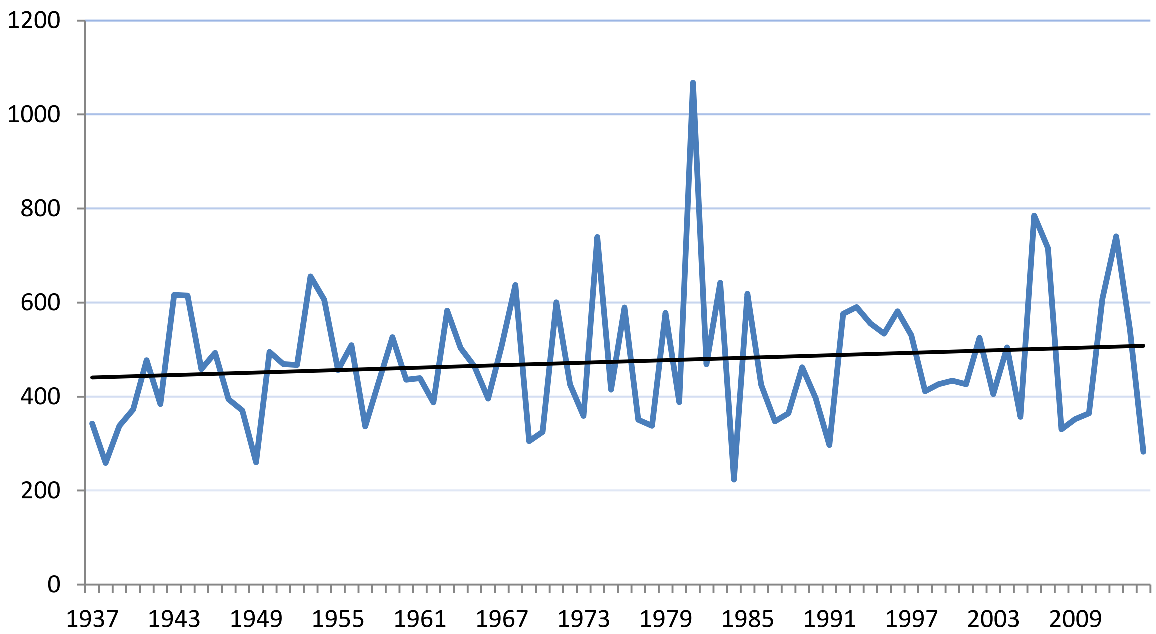


Figure 10. **Total amount of annual rainfall measured in Joubertina for the time period of 1937 to 2014. Data Source: Sam van der Merwe, 2014, personal communication.**

Similar to the two datasets presented previously, there appears to be no clear trend in amount of annual rainfall, albeit the amount of rainfall once again slightly increases over time. Average annual rainfall measured in Joubertina over this time period is 474 mm, and thus is considerably lower than the 630 mm that the dataset of UCT yielded between 1966 and 1988. When comparing only the years from 1966 to 1988 (and omitting 1983 – 1986), the two datasets still show a difference of 150 mm. Nevertheless, all three datasets agree with each other in so far as that there is: if anything, a possible slight increase in rainfall over time in recent decades; large inter-annual variation, highlighting the occurrence of extreme weather events and weather variability in the area; a trend that the wettest months in the Langkloof are generally towards the end of summer and the beginning of winter (March, April) and again in late winter (August).

5.1.3 Other information

The CSAG dataset also contains other climate information recorded in the Langkloof area. However, due to the high inter-annual variability and the lack of a longer record, conclusions are difficult. It appears that the amount of heavy rain days per month are declining over time, and the amount of dry days per month are increasing towards the end of the 1980s when compared to the time period of 1966 to 1980. However, the lack of data for the years from 1983 to 1986 presents a difficulty in analysing the data and hurt the robustness of the dataset.

Benhin (2006) in his research quantitatively assessed the impacts of climate on agricultural systems in South Africa. To this end, Benhin looked at records of 26 weather stations throughout the country. In 23 of those, average annual temperatures increased between 1960 and 2003, and in 13 it was a significant increase. He documented an increase in national temperatures of 0.13°C per decade between 1960 and 2003, with the largest increase taking place in autumn (+0.21°C) and winter (+0.13°C). Similarly, Kruger and Shongwe (2004) found an increase in annual mean temperatures of between 0.06 and 0.15°C in weather stations close to the Langkloof valley. These findings are further supported by Blignaut *et al.* (2009), who determined that the 10 years between 1997 and 2006 were 2 % warmer and at least 6 % drier than compared to the 1970s. Once again, a lack of reliable climate records prevented a comparison to decades further back than 1970. Moreover, Kusangaya *et al.* (2014) concluded that temperatures in South Africa have risen by around 0.12 to 0.31°C in average temperature per decade. They also found a notable decrease in cold events, accompanied by an increase in warm events, further indicating a trend towards an increase in average temperatures.

As far as rainfall data is concerned, the scientific literature is unable to document a clear trend towards a reduction or an increase in average rainfall over the past decades, although it was reported that the duration of warm and dry spells has increased; however, the lack of sufficient data complicates the issue (Kusangaya *et al.*, 2014).

5.2 Future Trends in Climate

Predictions of climate change on a global or continental level are becoming increasingly accurate and global climate models show clear signs of conformity nowadays. However, especially on a regional level, such as the Langkloof valley or even the Eastern Cape, the impacts of climate change are still difficult to predict, and models can differ greatly from each other. This is due to the fact that climate change acts on long time scales and is influenced by many different factors, that all interrelate to each other in different ways.

Furthermore, since climate change is interacting with many biogeochemical cycles globally, there is a significant uncertainty attached to climate predictions and models, as it is difficult to predict exactly how the interplay between geochemical cycles and the effects of climate change will pan out. Despite this, modelling climate and aspiring to create possible future scenarios is immensely important if humans are to adequately prepare themselves for an inevitable change in the global climate. Climate models function by analysing data from the past and projecting future trends. Thus, records of temperature, rainfall, humidity, and other factors are amassed and carefully examined. The model is then fine-tuned as many times as need be until its output for the past closely follows the actual climatic history of a region. This process is repeated a number of times with a change in many parameters and values, until there is a high enough confidence that the model is accurately tuned. Only once the model succeeds in successfully recreating past climate trends and changes can it be used to model future scenarios. Naturally, a projection of the future is heavily laden with uncertainties, which is why most models present multiple scenarios, each depending on the input parameters that it was given.

5.2.1 National Models

According to the fifth assessment report of the IPCC, a general increase of temperatures is to be expected in many African countries, including South Africa. Additionally, this warming in Africa is believed to exceed the average global warming, as drier subtropical regions warm more than moister tropics (Christensen *et al.*, 2007). Calzadilla *et al.* (2014) found it likely that South Africa would be exposed to higher temperatures, less rainfall, more climate variability, and a change in water capture, water runoff and soil moisture. These effects can then in turn influence other factors such as groundwater availability and CO_2 concentration. Amassing and analysing data from three climate models revealed a temperature increase in South Africa of between 2.3 to 9.6°C by 2100 (Benhin, 2006). This is in line with other researches, which document a rise in temperatures of approximately 3°C within this century (Kusangaya *et al.*, 2014, Hewitson and Tadross, 2011). Other studies found an increase in temperatures of around 2°C by the end of the century or earlier likely (Gbetibouo and Hassan, 2005).

As far as rainfall is concerned, projections are less homogenous. It is believed that Southern African rainfall will decrease during winter and spring, but for changes in summer rainfall the models differ greatly from each other (Calzadilla *et al.*, 2014; Johnston *et al.*, 2011). Furthermore, the existence of large climatic differences and micro-climates within South Africa make it difficult to confidently predict changes even for South Africa as a whole. The amount and timing of rainfall over South Africa is heavily linked to changes in Sea Surface Temperatures (SST) of the Indian Ocean, which are expected to rise. Increasing SST in the Indian Ocean also affects evaporation, which can contribute to a rise of water vapour over South Africa (Christensen *et al.*, 2007). As such, the scientific literature agrees that changes and trends in rainfall are much more local, and some regions in South Africa may well experience more precipitation in the future.

5.2.2 Eastern Cape Region

Below are shown two climate projections that depict expected temperature changes for the time period of 2046 to 2065 in summer and winter, when compared to a baseline of 1979-2000 (*Figure 11*) (Johnston *et al.*, 2011).

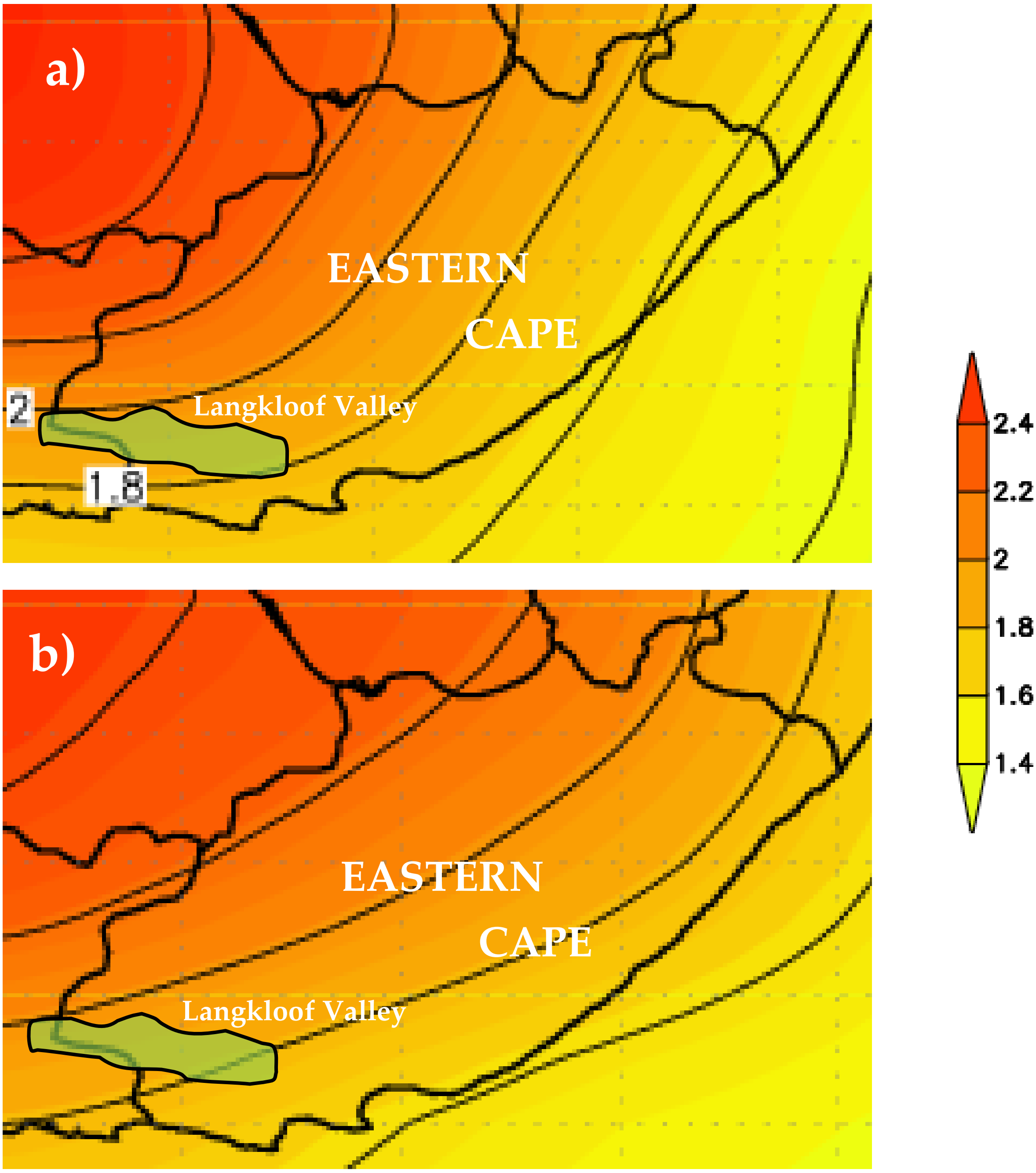


Figure 11. **Regional climate model data showing expected temperature changes for 2046-2065 for a) December/January/February, and b) June/July/August for the Eastern Cape region, when compared with the 1979-2000 period. In green is shown the location of the Langkloof valley. Modified from Johnston *et al.* (2011).**

As can be seen, average temperatures are expected to rise between 1.4 and 2.4°C in the Eastern Cape region within the next 30 to 50 years when compared to 1979-2000. Moreover, regions located further away from the coast are believed to warm faster. Additionally, Johnston *et al.* (2011) downscaled GCM data obtained from the WCRP CMIP3 Multi-Model Database in order to predict future trends in rainfall and temperature over the Eastern Cape region. They created maps showing the median values and range of values for each of the stations (Johnston *et al.*, 2011). In order to create these projections, their research used the A2

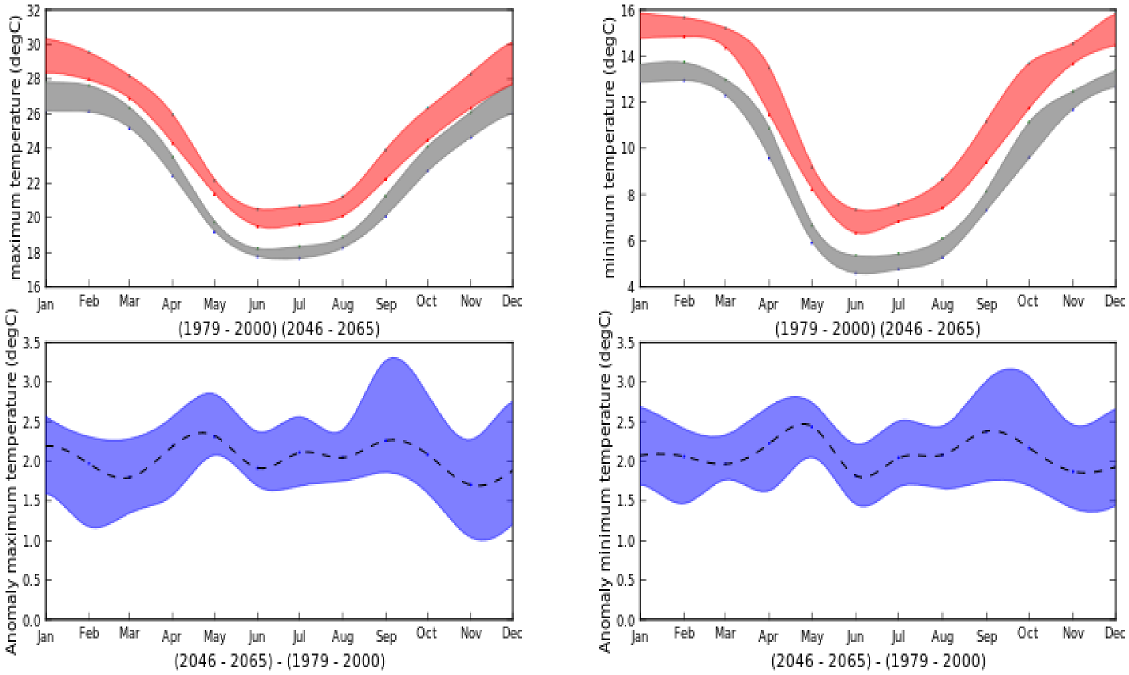


***Figure 12.* Observed and projected maximum (left) and minimum (right) temperatures for Willowmore. The top panel provides the 10th to 90th percentile multi-model range of monthly mean daily maximum (or minimum) temperatures for the 20th Century (in grey) and the future (in red). The bottom panel shows the 10th to 90th percentile multi-model range of monthly mean daily maximum (or minimum) temperature anomalies between the 20th Century and the future. From Johnston *et al.* (2011).**

emission scenario from the IPCC Special Report on Emissions Scenarios (SRES). All downscaled projections of monthly mean minimum and maximum temperatures show a significant temperature increase, and below are shown the projections for Willowmore, which is the closest investigated weather station to the Langkloof (*Figure 12*).

On average, the annual mean temperature is projected to increase by around 2°C in the coming 30 to 50 years in the Eastern Cape region. Stations closer to the coast experienced a smaller temperature increase than those further inlands, and minimum temperatures seem to increase slightly more rapid than maximum temperatures (Johnston *et al.*, 2011).

Figure 13 shows an average change in monthly total rainfall for 2045 to 2065 when compared to 1979 to 2000. The information was processed by downscaling GCM data, and by applying the A2 SRES scenario (Johnston *et al.*, 2011).

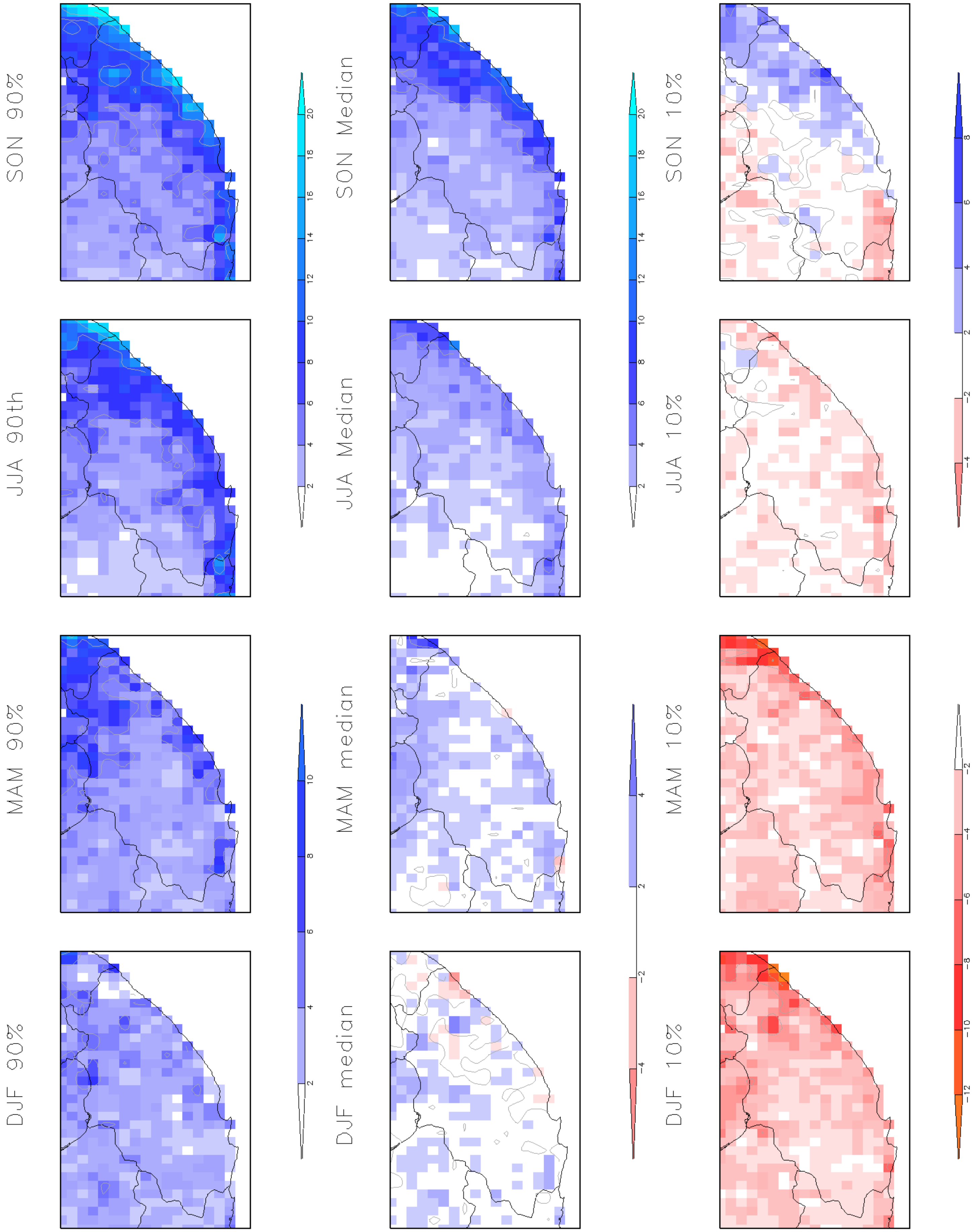


Figure 13. **Downscaled seasonal rainfall anomalies for the Eastern Cape: 2046-2065 compared with the 1961-2000 period. From bottom to top: seasons DJF, MAM, JJA, and SON. Variation from left to right: wettest 10 %, median and driest 10 %. From Johnston *et al.* (2011).**

It becomes apparent that median rainfall is largely projected to increase in the Eastern Cape region, although often there is no projected change. Largest rainfall increases are seen along the eastern coastline during winter (JJA) and spring (SON), whereas the summer and autumn months show little change in predicted rainfall. Hence, the models indicate that rainfall will slightly increase in the Eastern Cape region, and also slightly increase around the Langkloof area.

However, some studies also document a decrease in rainfall over the Eastern Cape region. Blignaut *et al.* (2009) report a decrease in rainfall of approximately 1.4 %, alongside a temperature increase of 3.8 %.

Other possible changes in the study area due to a change in climate included less soil moisture, changes in surface water runoff, and changes in carbon dioxide fertilization (Calzadilla et al, 2014).

In conclusion, climate models aiming to predict future trends in precipitation and temperature seem to indicate that:

- temperatures are likely to rise by 1.5 to 2.5°C by 2050, with inland regions such as the Langkloof warming faster than coastal areas
- temperature can increase by as much as 6 to 9°C by 2100
- largest warming is projected to take place during summer (maximum temperatures) and winter (minimum temperatures)
- frequency of extremely hot days will likely increase, whereas nights with freezing temperatures will occur less often
- rainfall will increase in the Eastern Cape region, and most likely also slightly increase in the Langkloof
- an increase in rain is predicted to happen during the rainy seasons
- projections concerning future rainfall trends are less certain than temperature trends and also display a weaker anomaly to 1979 – 2000 conditions than temperature
- changes in surface water runoff, carbon dioxide fertilization and soil moisture will occur

The literature also agrees that climate change may very well lead to more frequent extreme weather events in South Africa (Kusangaya *et al.*, 2014).

5.3 Climate Change Impacts

It is important to note that due to the inherent uncertainties that are attached to climate change, it is even more difficult to assess and discuss the impacts of such a change. Similar to climate change itself, its social impacts are influenced by a number of different factors, acting on different scales. Social impacts are always the result of a complex interplay of processes and developments in an area. Nevertheless, this chapter aims to address probable and possible impacts in the Langkloof that may arise from the climate predictions presented in the chapter above.

Most of the examined literature agreed that temperatures are likely or very likely to rise in the Langkloof in the near- and long-term future. Increases of at least 1.5 to 2.5°C are likely to take place within the next 40 to 50 years, and could even reach up to 6 to 9°C by 2100 (Gbetibouo and Hassan, 2005; Benhin, 2006; Blignaut *et al.*, 2009). Generally, higher mean temperatures result in increased evapotranspiration and decreased water balance, increased severity of droughts, and increased occurrence of harmful pests (Jaarsveld and Chown, 2001; DEADP, 2008). In combination with higher average temperatures, studies also found it likely that higher maximum temperatures and more days of extreme temperatures would occur in the Eastern Cape and the Langkloof (Benhin, 2006; Johnston *et al.*, 2011). This could lead to an increase and faster spreading of human diseases, to increased risks for fruit-, vegetable-, and livestock farming, to a higher frequency of fire and fire related damages, to increased electric cooling demands and reduced energy supply reliability, and to increased droughts and drought related risks (DEADP, 2008).

As discussed earlier, annual rainfall is projected to increase in the Langkloof, mostly due to increased precipitation during the rainy season. More frequent occurrences of heavy rainfall events during the rainy seasons would also increase the risk of floods. Additionally, if conditions were very dry prior to a flood, damages from flooding could increase, as soils could store less water during heavy rains. Aside from its immediate and negative consequences on agriculture, infrastructure and livelihoods, floods have additional negative impacts due to water logging, which can cause long-term damages to tree roots and soil quality (Calzadilla *et al.*, 2014).

Such changes could lead to many negative consequences within the Langkloof valley. It is more than likely that bio-diversity and the provision of many ecosystem services (e.g. provision of water, climate regulation, and moderation of extreme events) would continue to decline (Jaarsveld and Chown, 2001). Jaarsveld and Chown (2001) also document that 44 % of plant species and 80 % of animal species in South Africa could experience an alteration to their geographical distribution due to climate change. Further, they report a loss of opportunity cost, in so far as that an ongoing afforestation inhibits the country's possibility to benefit from carbon sequestration credits as proposed under the Kyoto protocol. It is also commonly perceived in the literature that the frequency of extreme weather events will increase in South Africa, as the climate system would become more erratic (Kusangaya *et al.*, 2014).

However, climate change would not only have adverse effects on ecosystems and their provision of services, but it would also have many other negative consequences on people's livelihoods. Human health could be heavily affected, as droughts and diseases such as Malaria could become more frequent, and the provision of health services could be inhibited as well (Jaarsveld and Chown, 2001). The generation of energy and the supply thereof could be negatively affected by climate change as well (Kusangaya *et al.*, 2014). Moreover, employment could decline, as popular employment sectors such as agriculture or industry could suffer (Benhin, 2006). But also touristic revenues in South Africa could potentially decline, which have been estimated at R 100 billion per year (Benhin, 2006). Small effects could also be felt in livestock production, as animals could be placed under additional stress due to temperature changes and less water availability (Jaarsveld and Chown, 2001).

Most importantly for the study area though, as the Langkloof is so heavily dependent on its ability to produce deciduous fruits, reduced agricultural production due to unfavourable climatic conditions could be devastating for the area. It is therefore concerning that agriculture in South Africa could be heavily affected by climate change. Higher temperatures and more frequent droughts would require additional irrigation of fruit orchards. And already 62 % of all of the water used in South Africa is attributed to irrigation (DWAF, 2004). If irrigation were to be increased in order to combat droughts and higher temperatures, further stress would be placed on the already limited water resources in the area. Furthermore, higher temperatures also shorten the crop cycle and thus could require a difficult adaptation process amongst farmers as far as their harvesting and growing cycle is concerned (Gbetibouo and Hassan, 2005; Benhin, 2006). As such, a reallocation of resources between and amongst different sectors may be needed, which is costly, time-consuming and complex (Gbetibouo and Hassan, 2005). Additionally, higher minimum temperatures in winter could reduce the number and frequency of days with frost. While the consequences of such a reduction could be both positive and negative, it would likely have adverse effects on the deciduous fruit farming industry in the Langkloof, as pears and especially apples require frost days during winter (Luedeling, 2012). Without these, it could be possible that some of the most lucrative varieties of deciduous fruit in the Langkloof may need to be replaced by other varieties (Benhin, 2008; DFF 1). Predictions that crop net revenues could decrease by as much as 90 % by 2100 exist (Benhin, 2006), although such a high number seems to be extreme and is not supported by other scientific findings. Blignaut *et al.* (2009) reported a more conservative number of a 2 to 16 % reduction in net revenues for the Eastern Cape, when considering a 2°C increase in temperature and a 5 % decrease in rainfall. However, as rainfall is projected to increase in most studies, this decrease of net revenues could very well be lower or could even increase.

Finally, it is important to note that a vulnerability to climate change of the Langkloof, and of South Africa as a whole, is further exacerbated by a low adaptive capacity, poverty, and low technological uptake (Kusangaya *et al.*, 2014). One article stated that in order for South Africa to adapt to the adverse effects of climate change, agricultural yield improvements of over 20 % are necessary (or about 0.4 % per year), when already assuming a standard increase in productivity of 2.7 % (Calzadilla *et al.*, 2014).

However, apart from the many negative consequences, climate change could also have some positive effects on the Langkloof. Today's climate change is accompanied by higher CO_2 concentrations in the atmosphere, which enhances plant growth and increases water use efficiency, especially in C3 plants such as deciduous fruits (Gedney *et al.*, 2006; Long *et al.*, 2006). This could counteract some of the previously discussed negative consequences of climate change on agriculture, although it is unlikely that it would entirely offset those consequences.

It is also interesting and important to note that other countries may well suffer more from the adverse effects of climate change than South Africa. It is possible that climate change will only lightly affect harvest yields and agricultural production in the Eastern Cape region, especially if precipitation were to increase over the Langkloof as some models predict (Gray *et al.*, 2013; Johnston *et al.*, 2011). As such, if climate change were to affect other countries more, it is possible that the Langkloof could benefit in the long-term, if the international markets and its demands are taken into account as well (Calzadilla *et al.*, 2014). Such assumptions however are difficult to make at this moment.

6 Stakeholder Analysis

In order to examine the social impacts arising from environmental- and climatic change, it was necessary to communicate with a variety of local stakeholders in the Langkloof. A total of 29 interviews were conducted in this research. This was facilitated with the help of Living Lands, and a first contact was oftentimes established through the already present network of said organisation in the Langkloof. Interviews were conducted during the months of October to December in 2014, and almost all were held in a personal conversation with the interviewee. Only for two governmental representatives was it impossible to meet in person. In those cases, information was exchanged via email. Moreover, three stakeholder meetings bringing together various experts, fruit farmers, and government representatives, were attended to facilitate further information and knowledge gathering and will also be addressed in this section.

In accordance with potential future projects of Living Lands, a primary target group of this research was the deciduous fruit industry in the Langkloof. The economic future of the valley highly depends on the exportation of high quality fruits, such as apples and pears, and a majority of the local population is employed in the agricultural sector. As such, thirteen fruit farmers from different settlements in the Langkloof have been interviewed and asked for their opinions on different social, environmental and industrial topics.

Further, eight representatives of government departments and of the local municipality within the Langkloof have been interviewed as well. Here, a focus during the conversations was put on social impacts and issues, administrative tasks, and sustainable management of the environment.

Moreover, eight independent experts were asked for their opinion and expertise on the aforementioned issues. Due to their neutrality and often very specific knowledge on different topics, they presented a valuable asset to this thesis, as they were able to provide new opinions and additional information on issues of controversy between the municipality and the fruit farming industry. Two of these experts were beekeepers, which were of particular interest due to the high dependency of fruit orchards on pollination services by bees and other insects.

The information collected during these interviews will be presented in three different subchapters, each addressing the views, opinions, concerns, knowledge, practices, and problems of the different stakeholder groups (i.e. Deciduous Fruit Farmers, Governmental Representatives, Experts). Each chapter will also include an overview of the major concerns and problems that each stakeholder group is dealing with, as well as address their opinion and perception on climate change. A fourth subchapter will then showcase issues that are of common concern to everyone and address the concerns presented in the earlier subchapters in greater detail.

6.1 Deciduous Fruit Farmers

The deciduous fruit farming industry is the largest employer in the Langkloof, and simultaneously the major economic activity in the area. Below is shown an overview of the different concerns of various fruit farmers (*Figure 14*). Furthermore, their perception and views on climate change were also examined and are addressed here as well. More detailed information about each farmer can be found in Appendix III – Overview of interviewees.

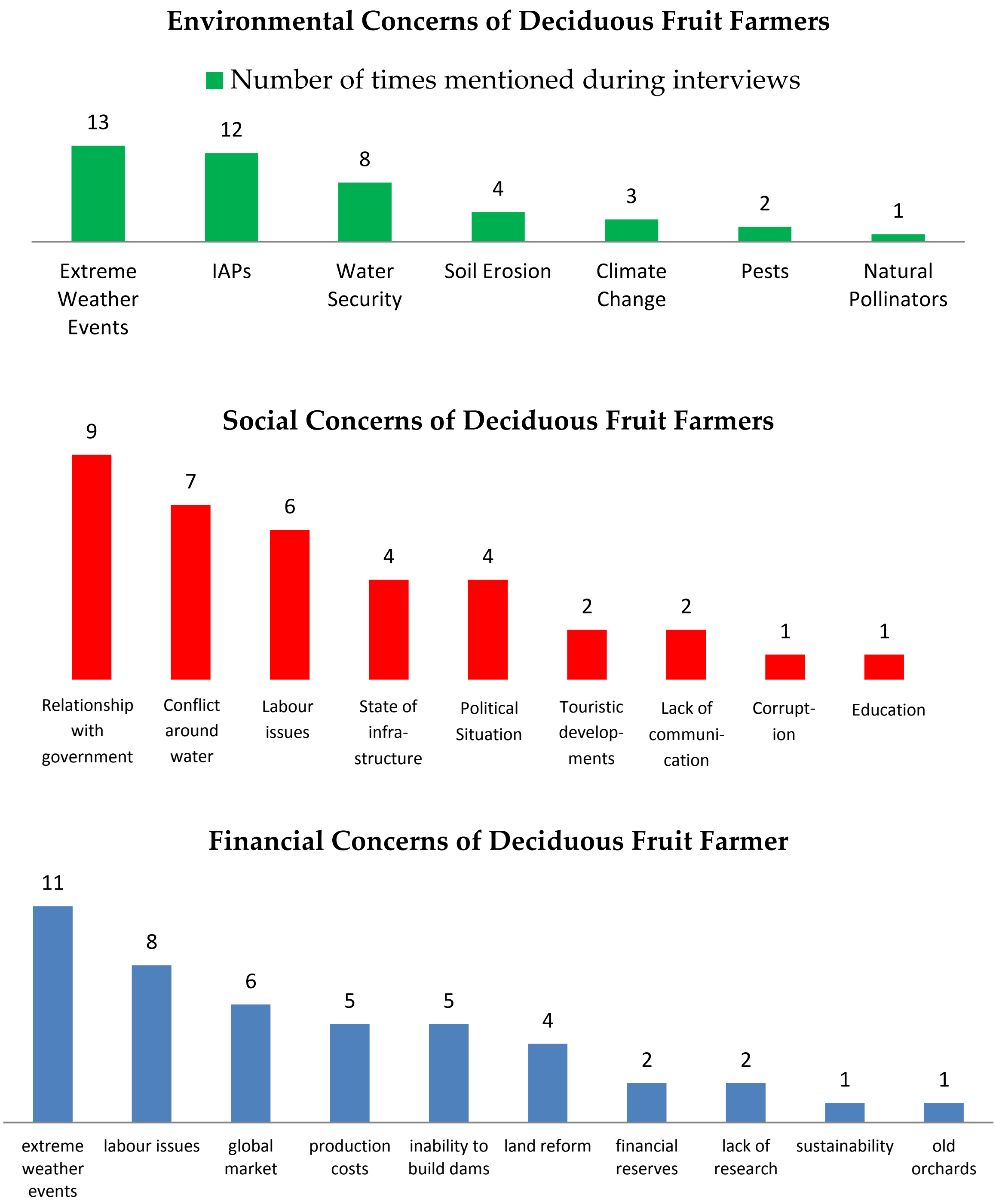


Figure 14. **Overview of main environmental, social and financial concerns of the interviewed deciduous fruit farmer in the Langkloof.**

6.1.1 Environmental Concerns

Not surprisingly, all thirteen interviewees named extreme weather events, such as hail, droughts, floods, and storms as one of their major environmental concerns. Being so heavily dependent on the right weather and climatic conditions, harvests can be negatively affected by such events. According to Haigh *et al.* (2004), the area is subjected to floods approximately once every 10 years. A flood in 1981 still comes to mind to many in the Langkloof (EXP 4). Unnoticed in the immediate aftermath of it, this flood caused major internal damages to the root system. In many fruit orchards, root were suffocated, exposed to pathogens and started to rot (EXP 4). Over the following years, the affected trees were less productive, and eventually, sometimes after as long as 10 years, farmers had to replace many trees at a great cost (EXP 4). Recently however, the Langkloof has experienced flooding in three of the past nine years, namely in 2006, 2007 and 2011, whereas the floods in 2006 and 2007 led to severe damages to local infrastructure and dams, as well as small crop losses (EXP 4). As a result of these floods, over 100 farm dams were damaged, of which many had to be repaired of even rebuilt completely (Sandbrink, 2013; DFF 7). The irrigation board in Haarlem, consisting of various farmers from the area, had to pay 2 million Rand for overflow repairs, and to this day the foundations of the dam are still damaged. The two floods in 2006 and 2007 have been called the largest floods in living memory by some (Sandbrink, 2013). While floods itself rarely destroy much of the harvest, they often cause damages to the trees and the tree root stock. As a consequence, during the years after floods, oftentimes such damaged trees produce less fruit, and eventually have to be replaced at significant costs. Some farmers (DFF 6, 8) were forced to replace whole orchards, and are as of now still replacing old orchards damaged by those floods. One farmer in Louterwater (DFF 13) calculated that the floods in recent years have cost him at least R1.5 to 2 million in repairs each.

Following these two flood years was a three-year period of droughts (2008, 2009 and 2010). The impacts of these droughts were further amplified through the damages that infrastructure and dams had taken during the floods in the years previously. Due to these damages, less water was stored and more water was lost due to leakage. Thus, less water was available for coping with the droughts that the valley was experiencing in those years. In Haarlem, the water level in the dam was below minimum level at a capacity of less than 20 % (Water Learning Journey). Farmers were forced to stop the irrigation of their orchards. Consequently, harvest yields were reduced and many farmers struggled to cope with these impacts financially (DFF 10). In the Eden district, which lies to the west of the Langkloof, the damages from these droughts have been estimated to exceed R 300 million (DEADP, 2014). Unfortunately, no such estimate is available for the Langkloof or the Eastern Cape, but this number still serves do demonstrate the heavy economic impact that it caused. A farmer in Louterwater (DFF 6) has reported that his production was affected by at least 30 – 40 % as a result of droughts in recent years.

Despite all this, the most worrying issue with extreme weather events amongst all interviewees was hail. All farmers agreed on the fact that hailstorms had the most severe impact on their yields, and for many it was their major concern overall. Hailstorms are sudden and largely unpredictable as to their direct location. Moreover, unlike with droughts, fires, and floods, it is almost impossible for farmers to prepare or mitigate damages stemming from hailstorms. Some farmers have installed hail nets in order to protect their orchards (DFF 10), but even those offer little resistance to large hailstorms. According to the fruit farmers in the Langkloof, there have been hailstorms at least once per year in the past nine years (DFF 2). A large hailstorm in 2006 caused crop losses in the Langkloof worth more than R 25 million (Sandbrink, 2013). A hailstorm in 2011 reduced harvests of some farmers by 80 %, while others stated that at least 50 % of their production was affected (DFF 1, 9). Other farmers have also lost a considerable share of their harvest to recent hailstorms, such as one in Avontuur in 2013, where at least 10 % of the harvest was destroyed (DFF 3). A farmer in Misgund (DFF 4) calculated that hail damages between 2006 and 2011 have caused him losses of at least R 12 million, which equalled his total turnover at the time. Additionally, only one week after this fieldwork concluded, there was a severe hailstorm in the Langkloof area (DA, 2014). The report found that almost all fruit orchards in Krakeel, Misgund and Louterwater were damaged, whereas each tree's fruit was damaged by 80 – 100 % (DA, 2014, see *Picture 3*).

***Picture 3*. Pictures detailing the extent of the damage suffered by fruits at the hands of the December 2014 hailstorm. Photo Source: DA, 2014.**

In total, at least 880 ha of fruit orchards have been affected, whose harvests are thus lost. This comes as a devastating blow to the region, especially as many of the fruits were only weeks away from being ripe for harvest. As a result, the report concludes that there will be no fruit export from this area for a period of one year, and even supply for the local market is unsure. Furthermore, smaller farmers, especially emerging farmers, are threatened with bankruptcy and might be going out of business due to this hailstorm (DA, 2014).

Apart from this, there have been approximately seven large fires in the area since 2007, with much more smaller ones as well, although they had no major economic or environmental consequences (GOV 3). Especially the fires spreading through the area following the 2008-

2010 period of drought have burned a large portion of the vegetation in the catchment area, as everything was very dry (EXP 4). These losses in biomass increased the amount of surface water runoff and thus increased soil erosion (EXP 4). Luckily however, none of these fires caused extensive damages to crops or farmlands. In mid-October 2014, during this field research, a fire broke out and spread from the Tsitsikamma Mountains into the Langkloof valley. According to one person in charge, approximately 450 ha of natural vegetation were affected, although farmlands have been spared. A number of farmers have reported damages to water supply lines or fences, but nothing more.

From these reports, it becomes obvious that the Langkloof is a disaster-prone area, and has thus, not surprisingly, been declared a disaster area a number of times in the recent past. In theory, disaster relief funds are to become available in the case of heavy damages as a result of natural disasters. As soon as an area such as the Langkloof has been declared a disaster area due to natural events, the department of agriculture is tasked with assessing these damages, after which a certain amount of funding becomes available to farmers in order to repair or rebuilt damaged infrastructure. Yet, despite the severity of extreme natural events in recent, many farmers have stated that they received little or no support from the government to cope with these disasters, with two farmers reporting that even after contacting the relevant departments of the government many times, no financial support was made available to the farmers themselves (DFF 7, 13). According to one expert, the money from disaster relief funds is mainly reserved for repairing infrastructure in the settlements, and not necessarily to support farmers (EXP 4). Thus, as the government is unable to cover all damages, there are few options left for farmers to cope with natural disasters. Moreover, due to the valley's vulnerability and sensitivity to extreme weather events, insurance premiums are high. Many farmers have only insured themselves after recent hailstorms, once they have witnessed the devastating effects it can have. Other interviewees have stated that they are currently not insured, or have only insured their most productive orchards. Hence, for many, farming in the Langkloof is a gamble with nature. As insurance is costly, many farmers have to live with the risk of losing much of their harvest to hailstorms and other events. It is therefore not surprising that all farmers have mentioned extreme weather events when talking about their most pressing concerns.

Another prominent issue that was mentioned during the interviews was the widespread occurrence of IAPs. While IAPs have less of a direct impact on agricultural productivity, they are nevertheless an important concern of farmers. IAPs, of which *A. mearnsii* (Black Wattle) and *H. sericea* (Hakea) are the most numerous, reduce surface stream flow, reduce the availability of water, increase soil erosion, and affect the soil composition negatively, amongst other effects (Dye and Poulter, 1995; Le Maitre *et al.*, 1996; Prinsloo and Scott, 1999; Holmes and Marais, 2000; van Wilgen *et al.*, 2001; Vilà *et al.*, 2011; Powell *et al.*, 2011). Hence, the spreading of IAPs has an indirect impact on quality and quantity of fruit harvests. The clearing of IAPs on their land is an activity that all farmers do. Most farmers clear IAPs by cutting them and applying chemicals in order to poison the remaining seeds (DFF 1). Some also use insects (weevils) and fungi to combat the spreading of IAPs (DFF 3, 5), while others use the cuttings for fire-wood (DFF 7, 9). Additionally, most farmers cooperate with the Working for Water program (WfW). In those instances, a WfW team visits a certain area once every few years, and cuts down the IAPs. However, a number of farmers have reported that alien plants start growing back soon after, which is why many have to clear their land at least once per year (DFF 9, 12). According to the fruit farmers, a reason for this re-growth is a lack of follow-up, a lack of efficiency in the efforts of WfW due to financial problems and work ethics, a lack of clearing mountainous and hard-to-reach areas (which leads to the spreading of seeds through the river), and a lack of communication between the WfW program and the farmers (DFF 1, 2, 4, 5, 6, 8, 11, 13). Additionally, many farmers and experts have stated that the WfW program only cuts down IAPs, but fails to remove them from the area. In riverbeds, this can lead to a clogging of the river channel, which in turn can increase damages from floods after heavy rains (DFF 13).

Soil erosion was also mentioned by a number of interviewees as an environmental concern. Human land-use change, the spreading of IAPs, and especially heavy rainfall events all contribute to increasing soil erosion in the area. Human activities, such as the conversion of natural land into cultivated land, the application of chemicals, and grazing have a negative impact on the ecosystem's ability to prevent soil erosion Furthermore, alien plant species increase biomass and out-compete native species (Richardson and van Wilgen, 2004), some of which help to prevent soil erosion through their deep roots (*Picture 4*) (EXP 2). Lastly, heavy rain leads to the dislodging of soil particles and a drastic increase in surface water runoff, which increases soil erosion. For farmers, soil erosion threatens their agricultural production, as rooting depth is decreased, soil structure is degraded, and nutrient balance is affected in most cases (Lal and Moldenhauer, 1987).

***Picture 4*. Example of how native plants with deep roots can counter-act soil erosion. Photo Source: Author**

Some farmers also mentioned pests such as *Fusicladium effusum*, which affects trees, or the potential decline in natural pollinators as environmental concerns. *F. effusum* is a fungal plant pathogen affecting fruits, stems and leaves and can develop in plants after heavy rains (Gottwald and Bertrand, 1982). They appear on the fruits as dark spots, and oftentimes reduce the quality of the fruit to a point where it cannot be sold. As a prevention measure, farmers in the Langkloof use chemical control to deal with it (DFF 7). Some farmers (DFF 12) are also worried about a potential decline in bee populations due to chemical spraying and a changing climate. As such, many have shifted their spraying cycle to night-times, so as to cause less of an impact on bees and other pollinators. Additionally, the majority of fruit farmers in the Langkloof also hire beehives from beekeepers in order to pollinate their orchards, which presents an additional expense to them. Depending on the variety, between 2 to 7 hives are needed per ha of fruit, and the moving of a beehive from one spot to another costs around 500 Rand.

Another environmental issue for a number of farmers was climate change. While not all farmers shared a similar urgency for and potency of a changing climate, for some it was one of the major threats concerning their future productivity. This issue will be further discussed in the chapter 6.1.4.

6.1.2 Social Concerns

Amongst the most popular social concerns was an unhealthy communication with the government and the municipality. Many fruit farmers even stated that communication with governmental actors had all but ceased because of bad experiences. Farmers perceived a lack of expertise and experience, lack of common interests, lack of provided services, favouritism towards emerging farmers, and distrust towards commercial farmers as the main reasons for this (DFF 1, 2, 4, 5, 6, 7, 9, 12, 13).

The distribution of water is perhaps straining the relationship between governmental actors and fruit famers the most, which is why a number of farmers have named the conflict around water as one of their main social concerns (DFF 1, 4, 7, 8, 9, 10, 11). Conflicts between government departments, the municipality and the fruit farmers are present on a number of topics however, which will be discussed in more detail later (subchapter 4). It has to be mentioned though that farmer from Haarlem and Avontuur officially belong to the Western Cape. Those farmers seemed to have a significantly better communication with their government representatives, than those of the Eastern Cape. In line with this, many interviewees have also reported that there is a lack of general communication between all stakeholders in the Langkloof. This includes a lack of collaboration between farmers themselves, the irrigation boards, governmental departments, the municipality and independent organizations and businesses. One farmer spoke of a fragmented community in the Langkloof (DFF 10).

Another prominent concern of farmers was labour issues. In recent years, labour strikes amongst farm-workers have increased throughout South Africa. Fuelled by labour unions, workers demand better working conditions, higher pay, and more job security. Farmers however doubt that the labour unions have the best intentions for the workers in their mind (DFF 13; EXP 4). So far, the Langkloof area has largely been spared of labour strikes, especially because many farmers stress that they strive to have a good relationship with their workers and offer them adequate payment (DFF 5, 6, 7, 13). Nevertheless, increasing labour costs are a concern for many farmers. Additionally, many farmers have cited problems with the reliability of their workers (DFF 2, 5, 6, 7, 8, 9, 13). Amongst the mentioned issues were problems with alcohol, not showing up for work, crime, and a lack of education.

Other social issues that were mentioned were the state of infrastructure, a lack of touristic development, education, the political situation, and a lack of support from the government. According to the interviewees, many dams, roads, bridges, houses and public buildings are in bad conditions (DFF 2, 5, 6, 7). As a result of this, living conditions for people are inadequate, settlements are in deterioration, and water is lost through leakages in pipes and dams (DFF 1, 7, 10). Many farmers also wished for more touristic development in the Langkloof (DFF 3, 5, 7, 11). A lack of education amongst the working class is another concern for fruit farmers. Some farmers would wish to delegate more responsibility to workers and promote them, but feel themselves forced to hire experienced (mostly white) managers and overseers due to a lack of responsibility and education (DFF 6). Additionally, the lack of education is also said to increase crime rate and alcoholism in the area, according to the farmers. Lastly, the political situation is a concern for many farmers as well. Political unrest can have consequences on labour developments, but can also impact water rights and land ownership.

6.1.3 Financial Concerns

Due to the economic importance of the agricultural sector for the Langkloof, it was imperative to interview fruit farmers about their most pressing financial concerns in the future. Unsurprisingly, the most common answer to this question was the threat of extreme natural events, which has already been discussed earlier. Not only is it difficult and expensive to prepare and cope with these disasters, but such events can also potentially destroy a large portion of a farmer's harvest, and even cause extensive damage to the fruit trees in the orchards. Another popular answer that has already been addressed earlier was labour issues. Essentially, without labour, fruit farmers are unable to harvest, process and package their fruits. Hence, the agricultural production in the Langkloof is highly labour dependent, especially due to the fact that much of the production chain is not mechanized.

A controversial issue that was mentioned a number of times during the interviews was an inability to expand farm dams, or to build additional dams (DFF 1, 5, 6, 7, 12). Having larger, higher, or additional dams would allow fruit farmers to better cope with droughts and would enable them to store more water after heavy rains. Currently, much of the rainwater during heavy rain is not retained, as water storage capacities are inadequate.

Another important financial concern was a rise in production costs (DFF 1, 2, 6, 10, 13). Fuel, electricity, chemical, tax, technology and labour costs have all risen in recent years, and farmers are worried that if the trend persists, their profitability might be endangered. Similarly, the global market situation was a worry for many farmers as well (DFF 1, 6, 10, 11, 12, 13). Especially the recent developments between the Ukraine and Russia have destabilized the European market. With relations between Europe and Russia being difficult as of recent, less fruit might be exported from Europe, resulting consequently in less fruit import as well. Thus, farmers have been advised to export less to Europe and focus on other markets, such as Russia or the Far and Middle East (DFF 1, 13). Additionally, the African market has expanded recently, which is why more fruit is sold in South Africa itself, and in other African countries (DFF 6). Price changes in the global market were another issue that was mentioned during the interviews. Essentially, the farmers of the Langkloof cannot dictate the market price and are thus dependent on it. However, farmers are mostly concerned about a shift or collapse of the global agricultural market, although it is no imminent worry for fruit farmers as of yet, as the global market is relatively stable (DFF 4).

Many interviewees also issued concerns about the land reform act of the government (DFF 2, 3, 4, 10). Called the Black Economic Empowerment (BEE), this land reform is a government initiative that aims to empower black farmers. As such, black farmers get allocated a piece of land, often previously owned by a white farmer, and receive financial and start-up assistance from the government. Due to the importance of this act for the future agricultural development in South Africa, it will be further discussed in a later section in more detail. The interviewed (white) commercial farmers show themselves concerned, and some fear that the government might take their land on which they have farmed for generations and give it to a BEE farmer (DFF 2, 3, 6). Despite this fear, no such form of land "grabbing" has happened yet in the Langkloof. It highlights though once again the strained relationship and existing distrust between fruit farmers and the government.

Other issues that were mentioned during the interviews included a lack of research, a lack of financial reserves and a replacement of old orchards in the future (DFF 3, 4, 5, 9, 11). In order to maximize harvest yields and farm effectively and sustainably, farmers keep themselves up to date with the latest technological developments, but some would wish for more research from South Africa itself, and name a lack of governmental support as a reason for the little ongoing research in the agriculture sector in their country. New internationally developed technologies however are quick to arrive in the Langkloof, so this was not a major concern for most farmers. A lack of financial research is an obvious concern for many farmers who struggle to profit from farming or who have to settle debts from the past (DFF 4, 6, 9). Such reserves are also needed to cope with natural disasters or labour unrest as well, and are an important financial concern. Two farmers also sold their farm to the government and are now managing it under the BEE enactment (DFF 4, 6). As a result of this, the farmers received financial aid from the government. Lastly, a replacement of old orchards is an additional expense that many farmers have to pay in the future. Due to recent developments, new varieties have been introduced to the market, and as such, farmers have to replace some of their old orchards to plant new trees. Also, some orchards are also damaged by hail, floods, fires, pests or through other ways, and are in need of replacement. Aside from the obvious costs of purchasing new trees and replacing old ones, farmers also have to carefully think about what kind of variety they want to introduce, and how the trees will be planted. Planting new trees is always an investment into the future, as a tree needs time to grow and requires a few years before it reaches full production (DFF 6).

6.1.4 Perception on Climate Change

Apart from the impacts of existing social and environmental issues, this thesis also dealt with the perception and potential consequences of climate change for ecosystems and people. As such, all interviewees were asked about their opinion and perception on climate change. Due to their vast knowledge on weather and the importance of it for agriculture, most respondents issued at least an underlying concern in regards to climate change. For some it was even one of the biggest concerns when looking into the future (DFF 1, 6, 7, 8, 9, 10, 13). These farmers were concerned about a reduction of cold units, a change in average rainfall and temperature, an increase of extreme weather events, and a change in the awakening time of trees. A reduction, or even absence of cold units during winter, could heavily affect the harvests of some fruits, especially apples. Apples and other varieties such as pears need a certain amount of cold units during the year. If minimum temperatures rise, and there are not enough cold units for a plentiful harvest, then farmers would have to replace many orchards and plant new varieties (DFF 1, 2, 7, 9, 10). Due to the fact that apples are the most prominent variety in the Langkloof, making such a change would only be possible at significant expenses, and new varieties might not sell or grow as much. Furthermore, a change in the average rainfall or temperature, or different awakening times of trees, could have permanent effects on the agricultural production in the Langkloof. Spraying cycles would have to be adjusted, as well as harvest times. Consequently, less fruits might be exported as the worldwide demand might change as well, or crop yields could be reduced, as seasonality might change in the Langkloof as well (DFF 1, 7, 8, 9, 10). More frequent extreme weather events such as hails, floods and droughts can also destroy harvests and reduce the economic viability of the Langkloof as a whole. Furthermore, smaller farmers, especially struggling emerging farmers, might be put out of business as a consequence, as they do not have enough financial capital to pay for insurance or new, expensive technology.

In order to cope with these threats, many farmers cite the need for climate research and better monitoring of soil, orchards, and weather, as well as the research for new and improved varieties as a must in the near future (DFF 1, 7, 10, 12). Other measures that were mentioned included the development of boreholes and the expansion of dams as a way to circumvent shortages of water, while others proposed the instalment of nets in order to cope with more frequent hail storms and greater sunshine intensity (DFF 6, 11). Only few farmers were unconcerned about climate change and doubted that it was happening (DFF 4, 12).

6.2 Government Representatives

Figure 15 gives an overview of the main environmental and social concerns of government stakeholders. Furthermore, reasons that led to an inability of the municipality or government departments to effectively carry out services were addressed as well, as this was a point of criticism towards the municipality and the government by many other stakeholders.

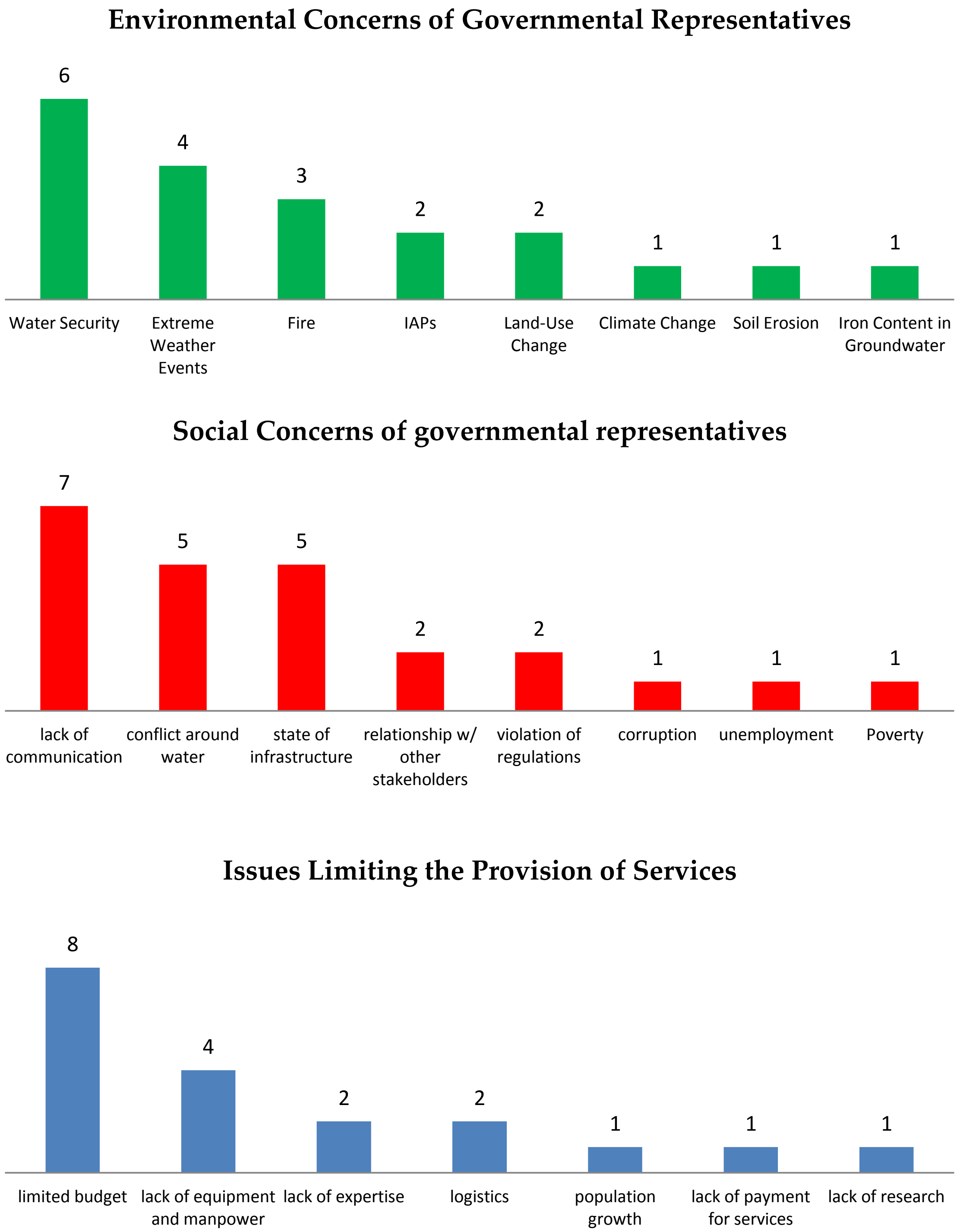


Figure 15. **Overview of main environmental and social concerns of interviewed government actors in the Langkloof, as well as an explanation of why services by the municipality were not always able to be delivered adequately.**

6.2.1 Environmental Concerns

For the eight interviewed governmental actors, that is, representatives of government departments or employees of the Koukamma municipality, the provision of water was the main environmental concern (see *Figure 15*). Due to a relative shortage of water in South Africa, the government is hard-pressed to supply enough water to their citizens. Even in the Langkloof, an area that benefits from the water supply of the Kouga catchment, only 90 % of the water demand of the settlements can be covered by the municipality (GOV 2).

Picture 5. **Damage to roads that have not yet been repaired. Photo Source: Author**

Apart from this, government representatives have named a number of issues that have already been mentioned by the fruit farmers. Amongst those are extreme weather events, the alien plant infestation, soil erosion, climate change, and the risk of fires. As these topics have already been discussed earlier, they will not be addressed in greater detail here again. Extreme weather events and fires both threaten human lives and livelihoods, as well as potentially severe damages to local infrastructure. Soil erosion is another threat to infrastructure, especially for the road network. There are roads that have been severely eroded after the 2006 and 2007 floods and that are not yet repaired (*Picture 5*). The infestation with alien plants reduces the supply of water in the area, and is therefore an important aspect for the government. Climate change on the other hand is a potential threat that can affect all the aforementioned issues. Higher temperatures can lead to a more rapid and more frequent spreading of fires, less available water, spreading of human and plant diseases, amongst other possible impacts.

Lastly, representatives of the department of environmental affairs are also concerned with the loss of wetlands in the Langkloof and the adjoining regions, and the increased intensity of human land-use. Both activities impair the ability of ecosystems to provide important services.

6.2.2 Social Concerns

The most common response when asked about social issues was a lack of communication between stakeholders in the Langkloof. Similar to how fruit farmers perceived the issue, governmental representatives feel there is substantial distrust between different parties, and not enough collaboration is taking place between stakeholders. All but one of the interviewees agreed on this. In accordance with this, there were also interviewees that wished for a collaborative water forum, where all stakeholders in the area could discuss issues around water, and common solutions could be found.

Another issue that was shared with the fruit farmers was the state of infrastructure in and around the settlements. Much of the infrastructure in the Langkloof is old and in need of replacements or repairs. For a country as water scarce as South Africa, losing a large portion of its water supply to inadequate infrastructure is devastating. Also a conflict around water was a popular topic that was shared with the fruit farmers. Water is the lifeline for the Langkloof, which is why there is a large conflict potential between the government and the farmers.

Unemployment and poverty, corruption, and a violation of laws and regulations were amongst other social concerns that government representatives had. Despite the large agricultural industry in the Langkloof, many citizens are still unemployed and live in poverty. As a result, small crimes happen from time to time, and alcoholism amongst the common people is a problem. Recently, farmers are required to apply for permits and have to conduct assessments (which can cost up to R 200,000 (GOV 4)) if they want to interact with nature on their land, which many fail to do. As a result, there is now more pressure on farmers.

6.2.3 Issues Limiting the Provision of Services

This section addressed issues that inhibit the ability of the municipality and the government to successfully and adequately provide their services. For the municipality, these services consist of a provision of water, maintenance of infrastructure and sewage systems, removal of solid waste and waste water, provision of electricity, responding to concerns of local citizens, and the provision of secondary facilities such as schools, sport grounds and libraries, amongst other tasks. It needs to be mentioned here, that electricity in the Langkloof is largely provided by the South African company ESCON and not the municipality, as ESCON is better equipped to provide electricity (GOV 2). The main services that the government aims to provide in and for the Langkloof are an effective response to natural disasters such as fires, hail, droughts, and floods, an allocation of funding to the municipality and the various government departments that are active in the area, capital projects, and training and support for emerging farmers and municipal branches. However, almost all interviewees agreed that these services cannot be fully provided in the Langkloof for a number of reasons. According to all interviewees, one primary reason for this was a limited budget. Due to insufficient funding from the national government, the municipality and the different government departments in the area are not able to solve all issues that require attention.

Furthermore, an increasing growth in the population in the Langkloof further complicates many of the services that the government and municipality aim to provide. One employee of the Koukamma municipality reported a population growth in the Langkloof of 2.5 % per year (GOV 1). Such an influx of people requires the building of new houses and the instalment of new pipes and drainage systems. It also increases the demand for water, which can already not be fully met as of today. The financial constraints also severely inhibit the ability to respond to natural disasters. For example, the fire department of the Koukamma municipality, serving an area of 2,300 km², consists of only 5 employees and one proper fire engine (GOV 3). Not surprisingly, in the case of fires, the assistance of the regional municipality is required. In that case, a join operation centre (JOC) is set up, and additional funding can be made available, as well as more support in the form of manpower and equipment. Additionally, the municipality is often dependent on the cooperation of farmers to deal with fires and other disasters, as farmers often have better equipment (GOV 3).

Another issue mentioned was the vastness of the area, and the accompanied problems with logistics (GOV 2, 3). Towards the end of the Nineties and in 2000, a large number of municipalities were merged (GOV 2). This decreased the number of municipalities from 800 to 200 (GOV 2). The goal was to reduce administrative problems and responsibilities, but, as a consequence, many new challenges presented themselves. Today, the municipal area of the Koukamma municipality comprises 3,600 km² (GOV 1). While satellite offices are present in all settlements in the Langkloof, the municipality is not properly equipped to deal with many rural problems further away from its head office in Kareedouw.

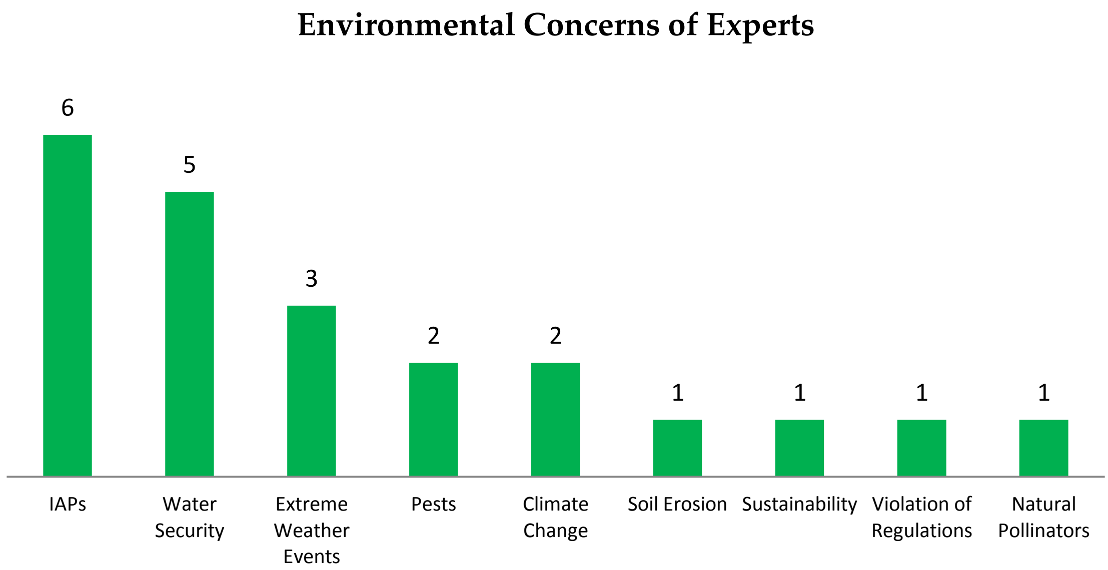
Other reasons that were named as to why services could not always be fully provided was a lack of expertise in the municipality and the government, a lack of payment for services, and a lack of manpower. According to one representative, many citizens, especially farmers, do not pay for their services (GOV 2). As a result, the municipality is not receiving as much income as they ought to, which consequently puts more strain on their financial budget. A lack of expertise and manpower can both be explained with the limited budget that is available. One expert also mentioned that knowledgeable and well-trained people have left the municipality in recent years and now work in the private sector (EXP 2).

6.2.4 Perception on Climate Change

When asked about their opinion and actions on climate change, all interviewees replied that they are not yet investing money or time as a preventive measure for climate change. Moreover, most respondents were of the opinion that climate change will not require any sort of special efforts or measures in the near future. Amongst those, two representatives showed themselves sceptical about climate change even taking place (GOV 4, 7), while others only issued small concerns in the future (1, 2, 5, 6, 8). Only one representative stated that climate change might turn into a major concern in the future (GOV 3). Amongst the perceived threats of climate change in the future were named the possibility of more frequent extreme weather events, a negative influence on livelihoods due to impacts on the agricultural sector, changes in rainfall, and the spreading of more fires. Undoubtedly, the government and the municipality faces more pressing issues at this moment, and the lacking finances, as well as a lack of experienced and well-trained men, overshadow the need to address climate change rather sooner than later (GOV 3). The provision of water, the livelihoods and employment of people, and the lack of communication amongst stakeholders are all issues that require more attention than potential impacts of climate change in the future (GOV 1, 7, 8).

6.3 Experts

Figure 16 provides an overview of environmental and social concerns as identified by local experts.



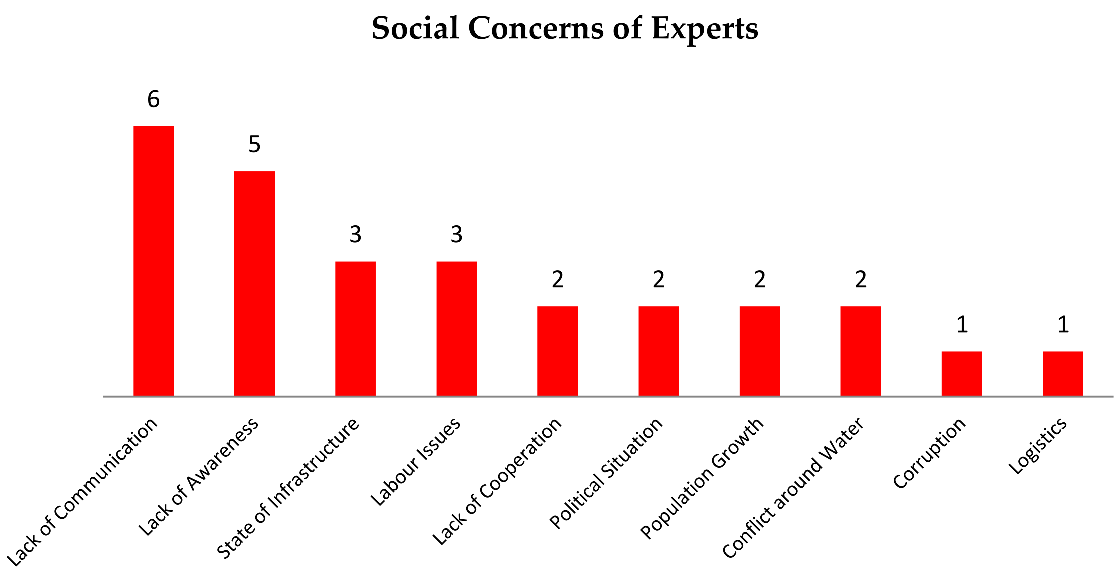


Figure 16. **Overview of main environmental and social concerns of interviewed experts in the Langkloof.**

6.3.1 Environmental Concerns

In order to be able to paint a clearer picture, it was essential to also interview a number of independent experts. These were able to provide an unbiased, expert opinion on a number of subjects. From an ecological viewpoint, the various experts all confirmed issues that had already been mentioned by governmental actors and fruit farmers alike. Amongst those, climate change, provision of water, invasive alien plants, and extreme weather events were identified as the most serious concerns (*Figure 16*). One interviewee from Haarlem reported that the clearing of IAPs is a major problem in the settlements of Haarlem and Avontuur. These two settlements belong to the Western Cape, and as a result, there are reportedly many administrative difficulties and barriers, which hinder clearing efforts of the WfW program in these settlements (EXP 1). Especially *H. sericea* (Hakea), moving eastwards from the George area is spreading more and more rapidly in the western parts of the Langkloof, especially along the mountain hills. IAPs are thus not being cleared thoroughly and in a timely manner in those settlements, meaning that many farmers are forced to clear on their own, which in turn has led to a violation of environmental laws and regulations in some instances (EXP 2). The consequences of extreme weather events and the difficulties of supplying water for settlements and farmers have already been addressed earlier.

Experts also mentioned soil erosion, spreading of pests, a potential decline in bee populations, and a lack of sustainable practices as other environmental concerns in the Langkloof valley (EXP 2, 3, 7). As far as soil erosion is concerned, one expert also added that the issue is intensified due to a lack of knowledge of stakeholders concerning the natural vegetation (EXP 2). In some cases, farmers pull out plants that they have identified as weed, not knowing that many of those plants actually have deep and strong roots, and help to prevent soil erosion. A consequence of this is that many roads in the Langkloof are currently affected by soil erosion. While a spreading of pests is generally not a major problem in the Langkloof as of right now, some experts are still worried that orchards and bees or other insects may potentially be affected in the future (EXP 7, 8). One expert, a beekeeper, went on to report that bee populations are currently in decline and named cold winters, pests and intensive cultivation coupled with the application of chemicals as a reason thereof (EXP 7). According to him, losses in bee populations have been as high as 30 %, although there are still many wild bee swarms to be found in the mountains. Another expert criticised a lack of sustainable practices amongst all stakeholders in the area (EXP 3). According to him, the municipality and the government do not possess adequate knowledge and experience about managing the environment, and farmers often indirectly harm ecosystems by interfering with nature.

6.3.2 Social Concerns

Similar to before, the various experts also confirmed many social concerns that were already voiced by government actors and fruit farmers, such as a lack of cooperation and communication, a population growth, the state of the infrastructure, a conflict around water between stakeholders in the area, the political situation, problems with education, and a lack of awareness amongst people, which have all been addressed earlier.

Additionally, issues with racism and corruption, a lack of long-term employment, vandalism, and problems with the disposal of garbage and waste have been raised during the interviews. According to one expert, racism between black and whites is still very much an underlying current in many social aspects (EXP 1). There were also concerns about labour and employment of people (EXP 2, 5). Most people in the Langkloof are employed in the agricultural sector, where people work on a seasonal basis, and many workers are migrant workers (EXP 1). These people are only employed for a number of months during the year, and some require social welfare during the period that they are not employed (EXP 1). The situation has definitely improved in recent years however. Before, many farm workers were only employed for three months during a year, but through the use of technology and because orchards and soils are now better monitored and treated in greater detail, most workers are now employed for at least eight months per year, as there is now more work needed in between the traditional pruning and harvesting seasons.

While vandalism is not an immediate concern for most, two experts have reported that beehives, fences and other small farm equipment sometimes become damaged through vandalism (EXP 7, 8). One expert also reported that because of a lack of awareness amongst people and an inability of the municipality to dispose of waste, in some settlements there is an acute garbage and waste problem on the streets (EXP 6). The situation is especially bad in Ravinia, a small settlement belonging to Joubertina, where reportedly the local residence association, with the help of many farmers, collected many tons of waste in an effort to clean it (EXP 6). However, only weeks later, large amounts of waste and garbage were back on the streets.

6.3.3 Perception on Climate Change

Throughout the interviews, the various experts largely showed a greater familiarity with the topic of climate change than the government representatives and most fruit farmers. All experts acknowledged that climate change would have to be addressed in the future, and for many it was one of their major concerns (EXP 1, 2, 3, 5, 7). All shared the impression that climate change would lead to negative impacts on livelihoods and agricultural revenues, as well as may increase the frequency of extreme weather events. Other additional impacts, such as a spreading of diseases, human health repercussions, less availability of water, and the requirement of new fruit varieties, were mentioned by the experts as well.

Out of the three here analysed stakeholder groups, the experts showed themselves to be most concerned with climate change, and also reported that they felt worried that the government has yet to take necessary actions to mitigate the effects of climate change (EXP 2).

6.4 Social Impacts

This section aims to discuss various aspects of the previously mentioned concerns and issues that have been identified during the stakeholder interviews. The purpose of this section is to address important issues from different viewpoints, and to highlight the importance of some issues for the Langkloof.

6.4.1 Identifying issues of importance

Due to the large size of the study area, its complex problem situation, and the many involved parties, it was essential to differentiate between issues of concern. It was not possible to address each individual problem that an interviewee had raised, as some of them were of minor importance or only relevant for one person or a specific area of the Langkloof. Thus, in order to facilitate such a differentiation, an overview was created to highlight the results of the interviews (see *Table 5* and *Table 6*). These tables list the various mentioned concerns and issues that stakeholders mentioned during the interviews, and rank them according to the amount of times they were mentioned and the importance they had for each stakeholder group. Hence, the first part of *Table 5* and *Table 6* is a representation of the number of times a specific issue was brought up by stakeholders. Due to the fact that more fruit farmer were interviewed than experts or government representatives, this is not an ideal representation of the importance of an issue. Therefore, the second part of *Table 5* and *Table 6* ranks each issue for each stakeholder group. This means that if an issue was commonly accepted to be important by a stakeholder group (e.g. extreme weather events for fruit farmers, or water security for government representatives), that issue would be ranked high amongst that stakeholder group. By adding up the rank of an issue amongst the different stakeholder groups, a relative ranking towards other issues could be created (e.g. extreme weather events ranked first amongst fruit farmers, second amongst government actors, and third amongst experts, and as such has a combined score of 6, which was the lowest combined score, and therefore attached great importance to that issue for the whole of the Langkloof). It is important to note that only issues that were mentioned by all stakeholders at least once were considered. *Table 5* represents an overview of the environmental issues, whereas *Table 6* corresponds to social issues.

As the social impacts of the various environmental issues have been discussed at length earlier, and because there is no similar conflict potential for these issues between the stakeholders in a way that exists for social issues, they will not be explained in detail again. Rather, a focus will be put on the social impacts of various issues, as these issues often affect different stakeholder group differently, or even cause conflict between the actors. The security of water, while being of environmental origin, will here be addressed as a social issue, as it greatly impacts the different stakeholders in the future.

Thus, this chapter will discuss a number of identified important issues in greater detail, and will describe the impacts this could have on the Langkloof in the future. Problems with the current state of infrastructure in the Langkloof will be included in the section that discusses the conflict around water, as much of the deficits in infrastructure pertain to this issue. Similarly, the relationship between stakeholders was included into the section that deals with communication issues. Furthermore, tourism and the BEE movement will also be addressed in this section due to the relatively large impact these issues may have in the future, despite not being named by all stakeholder groups. Nevertheless, it was felt that these issues should not be disregarded, and have therefore been included in this analysis.

***Table 5*. Overview of environmental issues as perceived by stakeholders. The first part of the table shows how often an issue was mentioned by the stakeholders, thus reflecting a sense of commonality. The second part of the table presents the importance of an issue for the stakeholders, thus reflecting a sense of magnitude.**

	Deciduous Fruit Farmer n = 13	Government Actors n = 8	Experts n = 8	TOTAL n = 29	
Environmental Issues	*Number of times mentioned by stakeholders*				
Extreme Weather Events	13	4	3	20	
IAPs	12	2	6	20	
Water Security	8	6	5	19	
Soil Erosion	4	1	1	6	
Climate Change	3	1	2	6	
Pests	2		2	4	
Fire		3		3	
Natural Pollinators	1		1	2	
Land-Use Change		2		2	
Iron Content in Groundwater		1		1	
Sustainability			1	1	
Violation of Regulations			1	1	
Environmental Issues	*Rank of importance amongst stakeholders*				
Extreme Weather Events	1	2	3	6	*1st*
IAPs	2	4	1	7	*3rd*
Water Security	3	1	2	6	*1st*
Soil Erosion	4	6	6	16	*5th*
Climate Change	5	6	4	15	*4th*
Pests	6		4		
Fire		3			
Natural Pollinators	7		6		
Land-Use Change		4			
Iron Content in Groundwater		6			
Sustainability			6		
Violation of Regulations			6		

Table 6. **Overview of social issues as perceived by stakeholders. The first part of the table shows how often an issue was mentioned by the stakeholders, thus reflecting a sense of commonality. The second part of the table presents the importance of an issue for the stakeholders, thus reflecting a sense of magnitude.**

	Deciduous Fruit Farmer n = 13	**Government Actors n = 8**	**Experts n = 8**	**TOTAL n = 29**	
Social Issues	*Number of times mentioned by stakeholders*				
Relationship w/ other stakeholders	9	2	2	13	
Conflict around Water	7	5	2	14	
Labour Issues	6		3	9	
Political Situation	4		2	6	
State of Infrastructure	4	5	3	12	
Touristic Developments	2			2	
Lack of Communication	2	7	6	15	
Education	1			1	
Corruption	1	1	1	3	
Violation of Regulations		2		2	
Unemployment		1		1	
Poverty		1		1	
Lack of Awareness			5	5	
Population Growth			1	1	
Logistics			1	1	
Social Issues	*Rank of importance amongst stakeholders*				
Relationship w/ other stakeholders	1	4	5	10	*4th*
Conflict around water	2	2	5	9	*2nd*
Labour Issues	3		3		
Political Situation	4		5		
State of Infrastructure	4	2	3	9	*2nd*
Touristic Developments	6				
Lack of Communication	6	1	1	8	*1st*
Education	8				
Corruption	8	6	8	22	*5th*
Violation of Regulations		4			
Unemployment		6			
Poverty		6			
Lack of Awareness			2		
Population Growth			8		
Logistics			8		

6.4.2 Conflict around Water

Perhaps the most prominent issue, and the one that creates the most controversy, is the distribution, future supply, and loss of water in the area. As already mentioned previously, the Kouga catchment, of which the Langkloof valley is a part of, is an important water catchment area. It supplies water to the settlements and the farmers in the area, but the water from the catchment is also essential for downstream users. Especially the agriculture in the Gamtoos valley and the Nelson Mandela Bay Municipality are dependent on it. Because of these needs, the government of South Africa has implemented a new National Water Act (National Water Act, 1998). Ultimately, this Act consigns the legislative right of water to the Department of Water Affairs and Sanitation. That is, the national government has taken ownership of the water in the country by shifting from private ownership to state ownership (EXP 3). Despite this, the national government still depends on the cooperation of other stakeholders to effectively manage and distribute water throughout the country due to a lack of management experience and a lack of manpower (EXP 1, 3). Thus, in the Langkloof, many water supplies, such as the water in the dam in Haarlem, are still mainly being maintained by local farmers. Farmers have a water use license, where they are allocated a certain number of m^3 of water depending on the amount of hectares that each farmer owns (EXP 2). While farmers are not required to directly pay for water, they still pay a levy to the government through the respective irrigation boards (DFF 9, EXP 2), and they have to pay for the pumping of water, and are thus conscious of how much water they use. Nevertheless, while the farmers are still managing the water in the Haarlem dam in the same way as they always have, many are now worried that at some point the national government might take over operations. One expert put it this way: "Farmers bought and built the dam with their own money, and now they're scared it will be taken away" (EXP 1).

According to an employee of the Koukamma municipality, only 90 % of the water demand in the municipal area is currently met (GOV 1). Thus, despite the fact that the Langkloof and the Kouga catchment are receiving more rainfall than other areas, and are amongst the water-richest areas in South Africa (Sandbrink, 2013; Veerkamp, 2013), not enough water is available to meet the demands. Reportedly, no water is available for an extended period of time in some settlements due to leaks and insufficient storage (GOV 2, 6; Formosa Stakeholder Meeting, 2014; Langkloof Water Learning Journey, 2014).

The primary water user in the Langkloof is agriculture. In Joubertina, during the most productive fruit seasons, 95 % of the water is used for the production of deciduous fruit (Langkloof Water Learning Journey, 2014). Officially, the local municipality in Joubertina only has access to 1/9th of the water in the Waboom River dam. Farmers require water from the dam during summer, when their own irrigation dams are running low. Conversely, from July to September farmers require very little water, and thus need much less water.

Additionally, farmers are judged to be very efficient at using water, as they are then able to produce more and lower their electricity costs (as they then need to pump less water) (EXP

2). All interviewed farmers reported to monitor their usage of water very closely, and all of them use micro- and drip irrigation systems. Those systems allow a very detailed water application to trees, which greatly reduces the amount of used water when compared to older irrigation systems such as overhead sprinklers (DFF 2, EXP 2). Farmer estimate that new technologies have helped cut the use of water per hectare by approximately 30 % (DFF 1, 10). Due to these technological advances, many farmers would wish to expand their orchards and build new dams (DFF 1, 5, 6, 7, 12) but report themselves unable to do so due to a moratorium on dams from 1992, which prohibits the building or expansion of dams in the Langkloof in order to save water for downstream users (DFF 1). However, contrary to the belief of some farmers, since the new water rights act has become effective, a moratorium like that does not exist any longer (DFF 10). Nevertheless, in order to be able to build new dams, a landowner would first have to go through a lengthy application process, including an ecological study and a thorough justification, amongst many other details (DFF 10). Hence, despite the efforts of several different farmers, only one interviewee stated that he was able to receive a dam license in the past few years, and that license was for a different farm, situated in the Western Cape (DFF 10). Nonetheless, farmers are making use of all possible options of gathering water. They use boreholes, buy it from other farmers, and even buy neighbouring, bankrupt farmlands just for their allocation of water (DFF 1, 6). "You simply need the water, it is your lifeline" (DFF 1).

One of the main reasons for the experienced shortage of water in the study area is the fact that water storage capacities are inadequate. During heavy rains, dams fill up quickly and then overflow, which means that as much as 80 – 90 % of the rainwater continues to travel downstream and eventually ends up in the Kouga dam in those cases (Langkloof Water Learning Journey, 2014) (see *Picture 6*). The issue is further intensified due to a lack of dams in the area. Dams only exist in Joubertina, Louterwater, Misgund and Haarlem, although the dam in Misgund has only just recently been built and pipes still need to be installed (DFF 4). The settlement of Krakeel does not have its own dam, and the dam in Louterwater has been judged to be insufficient and the quality of its water is an issue as well. An increased influx of "unofficial houses", (i.e. people erecting shacks and small houses on their own) has worsened the situation. These unofficial houses have reduced the water quality in the Louterwater dam

***Picture 6*. Built in 1969, the Kouga dam stores 129 million m³ of water and is the key water source for the Nelson Mandela Bay Metropolitan Municipality. Photo Source: Author**

by throwing waste and litter into its water (Langkloof Water Learning Journey, 2014). Furthermore, these houses are not connected to the pipelines, and, in the case of Louterwater, take their water untreated from the dam (Langkloof Water Learning Journey, 2014). Hence, the water issue is currently most serious in Krakeel and Louterwater (GOV 2). Also, many irrigation dams belonging to farmers have been built in the mid 1900s, and are thus old and insufficient (DFF 1). Ultimately, water storage capacities are not adequate.

Another worry in this regard is also the high iron content of the groundwater in the Langkloof. According to an employee of the municipality, the concentration of iron in the groundwater in the region is 23 mg/l, whereas officially it should be less than 1 mg/l. Even after treatment with chlorine, the concentration remains as high as 8 to 9 mg/l, which means that the already scarce groundwater resources are not ideally suited for domestic purposes, and serve little to alleviate the water shortages in the area (GOV 1). The high iron content is also damaging borehole pumps, which often have to be replaced after only one year of usage (DFF 6).

In order to combat these shortcomings, the municipality aims to build new dams in rivers, which has recently become possible after a moratorium from 1992, prohibiting the building of new dams, has been partially lifted (GOV 2). Thus, the municipality is now looking to build new dams in rivers and heighten existing dam walls (GOV 2).

An additional issue that complicates the water situation in the western Langkloof, namely in Haarlem and Avontuur, is that while the water officially belongs to the Eastern Cape (as it flows into it) and is managed by the department of water affairs and sanitation from the Eastern Cape, the settlements and its land and vegetation are part of the Western Cape. Hence, there is a lack of responsibility from the western and the eastern government departments concerning the water issues in those settlements (DFF 8; Langkloof Water Learning Journey, 2014). Maintenance for the dams and pipes is lacking in those settlements, as the responsibility for maintenance is unclear between the two Capes and the farmers. As of now, both the farmers and the George municipality of the Western Cape are maintaining the dam and the water infrastructure, but there are still many infrastructure related water issues in those settlements (EXP 1). As a result, many small-scale farmers have given up on their farms (Langkloof Water Learning Journey, 2014).

Loss of water for other reasons than lacking storage facilities is also a major problem in the Langkloof (GOV 1, 2, EXP 2). Loss of water it is the result of leakages and excessive water use (GOV 1, 2, EXP 2). One representative of the Koukamma municipality reported a loss of 41 % of the available water due to those two reasons. In another instance, a loss of 544,000 litres of water in Joubertina per day (with total consumption being 1,192,000 litres) has been reported by farmers, although this number has been doubted by the municipality (Langkloof Water Learning Journey, 2014). One expert also reported that he was aware of water losses as high as 175 % in some cases (EXP 2). In terms of infrastructure, one of the main reasons for these water losses lies with the toilet systems in the settlements (GOV 1). Particularly in those houses that have recently been built by the government in order to accommodate an influx of new citizens, the toilets are not working efficiently, and often water keeps running for extended periods of time. Despite ongoing efforts of the municipality to repair the toilets and old pipes, there is still a significant amount of water being lost in the meantime, as repairs are slow (GOV 1). To combat this, the Koukamma municipality has hired AURECON, a private company specializing in engineering, design and consulting, to repair and replace old infrastructure in Joubertina (GOV 2, EXP 2).

Excessive water use is attributed to a lack of awareness and a general ignorance amongst the citizens (Langkloof Water Learning Journey, 2014). Some citizens are reported to use purified water in their garden, for example (EXP 2). Incentives to reduce the amount of water that is wasted are not yet used extensively in the Langkloof. As previously mentioned, economic incentives to save water exist for farmers, as they can naturally produce more and save electricity if they reduce their water usage. However, citizens in the Langkloof are currently not required to pay for water, as it is subsidized for by the government (EXP 2, GOV 2). Consequently, people feel less need to save water (Langkloof Water Learning Journey, 2014). Moreover, water meters, detailing the exact use of water by a person or in a household, only exist in Haarlem, but not in the other settlements. Hence, it is impossible for the municipality to identify who uses the most water, and how much water is being wasted in each settlement. The municipality explains a lack of water meters in settlements with financial constraints (GOV 1). Due to a lack of budget, the municipality is unable to install the much needed water meters at present, although it hopes to do so within the next three years (GOV 1). As of now, the municipality is also busy with improving education around water in schools as a measure to hopefully reduce the amount of water that is wasted in settlements every day (GOV 1).

Most stakeholders agree that in order to solve this complex situation around water, it is imperative that all stakeholders meet on a continuous basis and discuss these issues and try to find solutions (DFF 1, 10; GOV 2; EXP 3, 4). It is for this reason that two independent research organizations from the area are proposing the creation of a collective Langkloof water forum. Both Living Lands and the Language of the Wilderness Foundation Trust (LOWFT) are currently busy with conceptualising and gathering support for their own version of a water forum for the area (EXP 3). This ambition has been welcomed by the municipality, the government, and the farmers alike (Langkloof Water Learning Journey, 2014; GOV 1,2,3; DFF 1, 10; EXP 3), although all stakeholder groups are apprehensive about taking a leading role in the creation and facilitation of such a forum.

Essentially, as the Langkloof region is currently already hard-pressed to meet its water demands, the situation will only worsen in the future, as many settlements are expanding. Water entitlements and allocation rights for water were issued in the early 1980s and have remained unchanged since then (DFF 1). As an example, at that time, Louterwater consisted of 50 houses, but that number has since grown to approximately 1,000 (GOV 2). Moreover, conflicts around water are further intensified by a lack of communication between the municipality (and, by extension, the regional and national government) and the fruit farmers, which will be addressed in the following chapter.

6.4.3 Communication Issues

A lack of communication amongst stakeholders has been mentioned as a key issue by all three stakeholder groups. Especially the relationship between the fruit farmers and the government/municipalities is strained. As far as water is concerned, the crux of the matter is that farmers need water for the irrigation of their orchards, the municipality needs it for the provision of sanitation and drinking needs in settlements, and the government requires the water from the Kouga catchment for agriculture, settlements and industrial activities further downstream. While each side claims to understand the other viewpoints, the government representatives stress the importance of the needs of Port Elizabeth and other downstream users (GOV 4), whereas the farmers highlight that because of a growth in population, the agricultural sector in the Langkloof needs to grow, as people need employment in the future (DFF 10).

Furthermore, farmers believe that as the Langkloof lies at the source of the water, its communities should not be the ones to lose out in the end (DFF 10, 13). It is a popular opinion that if the current trend of saving water for downstream users continues, then the Langkloof could suffer and eventually decline (Langkloof Water Learning Journey, 2014). Some fruit farmers also think that as they have not caused the problem, the responsibility to find a solution lies primarily with the government (Langkloof Water Learning Journey, 2014). "Whoever caused it, should fix it" (DFF 13). Farmers are also unhappy with the lack of governmental support (DFF 10). Despite the fact that the Langkloof has been affected by various floods, droughts, fires and hailstorm in recent years, the fruit farmers claim that they have received virtually no support from the government in the form of disaster relief (DFF 10). When asked about their relationship with the municipality and the government, there was a general consensus amongst most farmers that communication was bad and largely in vain (DFF 1, 2, 4, 6, 7, 9, 12, 13). Fruit farmers attributed this to a number of reasons:

- A lack of competence in the government which spreads to the local municipalities (DFF 1, 2, 5, 6, 7, 12, 13)
- A lack of experience and knowledge concerning the Langkloof area and its various issues (DFF 4, 7, 9)
- The Municipality only communicates "when they want something" (DFF 1)
- The efforts of the government to empower black farmers, despite the fact that the current model is likely to fail (DFF 1, 10)
- Salaries that are too high and leave not enough budget to improve the important environmental and social issues in the Langkloof (DFF 1)
- A long wait for responses (DFF 4)
- A lack of support to cope with extreme weather events (DFF 7,8, 9, 13).

Some even went so far as to call communication with government representatives or the municipality a waste of time (DFF 2). Additionally, the new National Water Act has given ownership of all water in the country to the government, which further intensifies a feeling of mistrust from farmers towards the government (EXP 1).

Similarly, government representatives also report that communication with fruit farmers is difficult (GOV 1). Employees of the Koukamma municipality claim that farmers are unwilling to share their knowledge and that they generally fail to inform the authorities on many important issues (GOV 1, 8). A lack of knowledge about impacts of farming activities on the environment have also been mentioned (GOV 4, 5). The government representatives also stress the importance of downstream users, and how the main importance of the Kouga catchment area is to provide water for the Nelson Mandela Bay Municipality (GOV 4).

Apart from these obvious communication difficulties between the government and the fruit farmers, there also exist many barriers between these actors and other stakeholders in the study area. Many respondents have indicated a lack of collaboration amongst stakeholders (GOV 1, 2, 4; DFF 10, 13; EXP 1, 2). According to one interviewee, stakeholders in the study area work mainly separated from each other, with different goals and each group focuses on different issues than other groups (GOV 1). There is no unity between stakeholders in working towards a common goal. Despite this, some interviewees responded that they can now see slight improvements in communication, which they largely attributed to a better personal relationship between individuals (GOV 2, 3, 5; EXP 2, 3; DFF 4, 6). Nonetheless, some fear that if government representatives that have managed to build a trust over the years will be replaced or retire, then much of the current progress could very well be lost again (GOV 3). Communication between WfW and the other stakeholders has also been judged to be insufficient (DFF 1, 6, 8; GOV 2, 8; EXP 3, 4). While all respondents appreciated the efforts and the ambitious goals of the WfW program, many have doubted its effectiveness. It has been criticized that there is no structure for communication (DFF 6; GOV 2), that the clearing is not thorough (DFF 2, 4, 9), that it is mainly a job creation mechanism (DFF 2; EXP 4), that their efforts are not sufficient (DFF 1, 5), and that the failure to remove the cut material can result in larger damages after floods, as the river channels can become clogged (DFF 13). Similarly, the WfW program states that communication with the other stakeholders is difficult from their viewpoint as well (EXP 5).Conflict also exists between livestock and fruit farmers, and conservationists. The latter would like to see the introduction and preservation of wild animals and nature reserves, whereas the former see wild animals as a threat for their production (EXP 2).

However, communication issues are not only present between the stakeholders, but also amongst them. During a meeting that brought together various water users and government departments, it has become clear that the communication between the different departments is problematic (Langkloof Water Learning Journey, 2014). This is perhaps highlighted best by a report that one employee of the department of environmental affairs made. He told of an occasion where a farmer received R 1 million in compensation for flood damages, which the farmer later used to channelize a small river and transform a wetland, for which he was lacking an environmental permit. The farmer justified his actions by explaining that he got the approval from the department of agriculture, of which the department of environmental affairs knew nothing about (GOV 4). Responsibilities for various issues are often shifted between different departments, and a common consensus is seldom reached. Interestingly, all but two of the eight interviewed government representatives reported difficulties in communicating with their superiors in the national government. Many employees of the municipality and workers of government branches have stated that there is a lack of assistance on a detailed level, and that the national government is not familiar enough with the issues and the complexity in the Langkloof (GOV 1, 2, 3, 4, 8). Interviewees stressed the importance of better communication channels (GOV 5) and more feedback from the national government (GOV 8). Communication between the government departments and the local municipality appeared to be better, although interviewees still agreed that it needs to improve in the future (GOV 1, 4, 6).

But also the fruit farmers are far from representing a common voice and a coherent entity. One expert told that a few years past, the department of agriculture provided R 70,000 to the agricultural sector in the western parts of the Langkloof (EXP 1). However, due to many internal disputes and differences, and because small-scale farmers (i.e. smaller fruit farmers, vegetable farmers, honey farmers) boycotted meetings, the various farmers were unable to agree with each other on where to use the funds. Ultimately, the department of agriculture retracted the funds. One farmer speaks of a fragmented community in the Langkloof (DFF 10). Each settlement and all different irrigation boards have developed around the small rivers in the area, and are thus to some extent isolated in their needs and concerns from the other communities (DFF 10). This is different in other areas in the Eastern Cape, such as the Gamtoos valley, where there is only one irrigation board and only one water source.

It is for this reason that farmers, but also the municipality and the various government departments, are interested in creating a collective water forum, where all opinions can be discussed and the interests of the Langkloof can be voiced by a single body (GOV 1, 2; DFF 10).

6.4.4 Racism and Corruption

While the fall of the apartheid regime has helped greatly to reduce racism and empower black people, an undertone of racism can still be felt in many instances. Farmers distrust the (mostly) black employees of the various government departments because of a perceived lack of expertise and the inability to speak the Afrikaans tongue, whereas many government employees have a negative opinion on farmers as they sometimes believe farmers are still in the mind-set of the apartheid era (EXP 1). Such underlying prejudice between two important stakeholders obviously complicates meetings and makes it difficult to find a common ground. One (white) government employee also reported how black colleagues with much less experience and knowledge have been promoted ahead of him, while he has been denied promotion three times (GOV 4). One expert also recounted that a black council member in Haarlem openly said "we hate white people", and that black vegetable farmers believe that white commercial farmers "turn off the water of black people" (EXP 1). These examples should showcase the racial problems and prejudices that still very much exist in South Africa today.

Corruption in the government and the municipalities has also been mentioned in the interviews. - One government representative recounted how an environmental impact assessment (EIA) was not conducted thoroughly in order to faster approve the building of new houses (GOV 4). He also mentioned how bribery is common to influence and speed up a decision-making process and spoke of "political bulldozing". Other interviewees noted how 70 % of the governmental and municipal budget is spent on salaries, and only 30 % is used to improve the livelihoods of people (EXP 1, 6). Many fruit farmers also believe the government to be incompetent and corrupt (DFF 2, 13), further highlighting the poisoned relationship between the two.

6.4.5 Tourism

During interviews, respondents were also asked about their opinion on tourism as a possible future development in the Langkloof area, which many thought had potential and should be developed more (DFF 3, 4, 5, 6, 7, 10, 11; GOV 2, 3; EXP 3, 4). A potential for eco-tourism was mentioned, as many hiking trails and mountain bike roads exist in the area (GOV 2; EXP 4). Agro-tourism as an additional benefit from tourism was also mentioned (DFF 7). Similar to wine-tastings, tourists could be introduced to new fruit varieties on farms (DFF 7, 10). Respondents also highlighted the diversity of the Langkloof area, and guesthouses would enable tourists to spend a few days enjoying the scenery (DFF 5). The potential for employment in the touristic sector for the months in which less people are working in the agricultural sector was another potential benefit (Langkloof Water Learning Journey, 2014). Nevertheless, most respondents indicated that while tourism may have potential, the fruit farming industry would very likely not be able to greatly benefit from it (DFF 1, 3, 4, 6, 9, 12). Also, it should not be a priority as of now, as there are more pressing issues that need to be dealt with (GOV 1).

6.4.6 Black Economic Empowerment & Joint Ventures

After the end of the apartheid regime in 1994 and the following transition period, the new South African government decided to directly support certain disadvantaged groups in society. More specifically, the government wanted to monitor and to some extent control the distribution of assets amongst the different social groups. It was for this reason that the government implemented the Black Economic Empowerment (BEE) programme in 2003, after having agreed upon it in 2001 (Broad-Based Black Economic Empowerment Act, 2003). While this Act also included other ethnic groups such as Indians and Chinese, it is mainly directed towards Blacks. Adjustments to the programme were made in 2007, although the basic framework remained the same, namely: "[The BEE] is aimed at redressing the imbalances of the past by seeking to substantially and equitably transfer and confer the ownership, management and control of South Africa's financial and economic resources to the majority of its citizens. It seeks to ensure broader and meaningful participation in the economy by black people to achieve sustainable development and prosperity." (BEE Commission Report, 2001).

What this means for a region such as the Langkloof is that the government allocates property and funding to black entrepreneurs, in order to enable them to successfully farm in the Langkloof. The local branch of the department of agriculture is mainly engaged at supporting these so-called emerging farmers (GOV 8). The department financially assists emerging farmers with products and inputs. Approximately 20 – 30 % of the chemical needs of emerging deciduous fruit farmers are paid for by the department (a larger number is not possible due to financial constraints of the department) (GOV 8).

The implementation of this Act eventually led to the introduction of a number of emerging farmers in the valley. One expert, who used to work closely with emerging farmers during his tenure at the department of agriculture, reported that the project started with around 20 BEE farms (EXP 4). However, nowadays he judges the number of somewhat successful projects to be five at best (EXP 4). An employee of the department of agriculture explained that there are six emerging farmer in the Langkloof, of which three however are part of a joint venture (GOV 8). Joint ventures will be addressed in a later section of this chapter.

When asked about potential differences between emerging farmers and commercial farmers, one expert noted that emerging farmers are using the same technologies and same chemicals (GOV 8). However, due to financial and logistic constraints, emerging farmers are often dependent on the help of commercial farmers in the form of advice, storage, and packaging (GOV 8). Some emerging farmers also struggle to complete their spraying cycles, as their equipment is old and often in need of maintenance (GOV 8). A lack of financial reserves also meant that only few emerging farmers were or are currently insured (GOV 8). As a result, the many extreme weather events of the recent decade have heavily affected emerging farmers. Harvest yields were reduced and most BEE farmers had to pay for the damages themselves. Hence, many emerging deciduous fruit farmers went out of business (GOV 8). Some emerging farmers also hire labour during the holiday seasons in May and June to prune their trees (EXP 4). During this time, the commercial farmers require less labour, and thus more is available at lower costs for emerging farmers. Also, as mentioned previously, despite the many examples of cooperation and mentoring, many black farmers (especially livestock and vegetable farmers) feel that their needs are pushed behind those of the white commercial farmers (EXP 1).

An initiative that has seen more success and still falls under the umbrella of the BEE movement is the creation of joint ventures (EXP 4). In those cases, emerging farmers and a white commercial farmer join forces. Thereby, a black farmer or a number of black shareholders partially own the land and thus earn a share of the profits, while most of the managing is carried out by a more experienced commercial farmer, although shareholders are still consulted when decision are to be made (DFF 6; EXP 4). Oftentimes, joint ventures are born out of the financial problems of a commercial farmer. In most cases, the land was previously owned by a white farmer, who then fell on financial hardships for a number of possible reasons, such as hailstorms, bad harvests or strong competition. Eventually, in order to settle their debts and to keep on farming, some farmers decided to sell their land and join forces with emerging farmers. While they thus give up sole ownership of their farm, they receive financial aid from the government. According to one farmer, he received R 10 million at first, and later another R 13 million after selling his farm and joining the BEE programme (DFF 4). Some interviewed farmers (commercial white farmers) also noted that they see a better future for joint ventures than for BEE farms that are solely owned and managed by a black farmer (DFF 1, 2, 4). In their opinion, black farmers lack the necessary knowledge and experience to farm successfully in the Langkloof, and eventually the value of the farmland will decrease due to bad management (DFF 2). Nevertheless, there are also fruit farmers who are unhappy about these recent developments. They are concerned about a potential "land grabbing" of the government. They fear that the government could strip white farmers of their land rights at any time and allocate it to black farmers (DFF 3).

7 Discussion

When examining a complex situation in a short time-span, both in terms of environmental and socio-economic changes, assumptions have to be made regarding some of the data. These assumptions and the associated uncertainties are the subject of the first section in this chapter. Then the implications for the results and the comparison with the examined literature, as well as research limitations that were encountered during the field research are discussed in a second section.

7.1 Discussion of Methods

7.1.1 Integrated Ecosystem Assessment

An IEA (Integrated Ecosystem Assessment)-approach was used to identify the key ecosystem services on which many of the human activities in the Langkloof heavily depend. A limiting factor of this approach was a lack of time and the logistic constraints. The field research spanned a three month period in South Africa, but the research station was based two hours outside of the study area. Further, vehicles were not always available and the amount of driveable kilometres was limited. As a result, only a few trips to the study area were possible. Consequently, it was not possible to obtain much quantitative data, especially as much of the surface area of the Langkloof was inaccessible by car. Information concerning the use of ecosystem services stemmed from a limited number of stakeholder interviews in the area and supplementary local literature which has a rather high level of subjectivity, uncertainty and ambiguity. Some respondents stressed the importance of one ecosystem service, whereas others deemed a different service to be of utmost importance. Quantitatively ranking or categorizing ecosystem services was therefore not possible, nor was it feasible to attach a monetary value to different ecosystem services, as no such information was available in the literature, and interviewees opinions on the matter showed large differences. However, as the intended scope of this thesis was to provide an overview of the area, such shortcomings were not of crucial importance. Moreover, the fact that opinions of stakeholders differed on the matter was helpful for constructing a realistic picture of the needs and interests of various stakeholders.

7.1.2 Stakeholder Analysis

The stakeholder analysis aimed to provide an overview of the different needs and views of various actors in the area on the most important topics. Further, it attempted to deliver insights into how people's livelihoods are affected by different social and environmental issues now and in the future. This thesis focused on three separate stakeholder groups: Deciduous Fruit Farmer, Government Representatives and Experts. The decision to focus on these actors was made for the reason that they represent the main actors in the area.

By focussing on these three primary stakeholder groups, it was not feasible to include other, less important actors within the area, such as vegetable farmers, other industrial activities, companies and bureaus, or different social groups. Their views are therefore probably underrepresented, which should be considered when interpreting the results. Furthermore, the different stakeholder groups do not form one coherent opinion, but rather, different individuals of the same stakeholder group can carry widely different opinions and views. Distinguishing between these opinions and finding a common thread is difficult, which creates uncertainty. Due to time constraints, it was also not possible to collect information from all available individuals or all relevant departments. Thus, the views presented here may not include all opinions of all stakeholders, but great care was placed to interview multiple individuals from different stakeholders in order to average out “unique” opinions.

7.1.3 Climate Change Analysis

An important aim of this thesis was to investigate the potential future impacts of climate change on the ecosystems and the livelihood of people in the Langkloof. Especially in the Langkloof, an area that so heavily depends on agriculture and is increasingly affected by a shortage of water, climate change may very well have serious repercussions in the future.. However, as always when dealing with the future, uncertainty remains in the analysis. Especially in a complex system, such as future climate, it is extremely difficult to accurately and confidently predict future trends. Different natural and human processes can influence the climate system, and small variations in these processes can heavily affect the future. In order to limit these uncertainties, this research collected information from different sources. The various predictions from these different sources were then integrated and examined with the goal to distinguish similarities and differences. A general trend that arises from the literature and the available data was then created to arrive at a most likely future scenario. However, the gathered information was often based on incomplete data or relied on different assumptions. In South Africa, not many long-term climate records are available. Furthermore, projections were not always available for the Langkloof valley, as there is no official weather research station in the area. While the information presented and discussed in this thesis was deemed indicative of likely future developments in the area by many stakeholders (GOV 2, 3, 6; EXP 2,3; DFF 1, 2, 3, 6, 8, 9, 10, 13), slight differences in the presented climatic trends are likely. Ultimately, when addressing consequences and impacts of future climate change, uncertainties are always part of the equation. These uncertainties were then taken into consideration in the writing of the results and were addressed. Despite the uncertainties of some results presented (as is unavoidable), a coherent picture could still be painted as different sources were used for each topic. An extensive literature research thus helped to substantiate the results and reduce the degree of uncertainty.

7.1.4 Risks and Opportunities Analysis

This part of the analysis was the result of a combination of the accumulated information obtained through the other used methods. Its goal was to address the major environmental issues in the area and to provide a first overview of possible adaptation options. Thus, this analysis is affected by the same uncertainties and limitations as the already discussed methods. That is, the information collected and processed in this analysis stems mainly from a limited number of individuals and scientific sources. Especially as far as the opinions of individuals are concerned, they are highly subjective and are not scientifically robust. Nevertheless, despite the fact that opinions of local stakeholders might be biased or not always fully informed, representing these views is important. Without clarifying what preference stakeholders have in approaching an issue, and without highlighting how stakeholders perceive the services and benefits of nature, it is impossible to find a sensible solution for the area. A successful management or development strategy can only be identified and implemented if the views and concerns of stakeholders are taken into account, even if they are not entirely justified or reasonable. Nonetheless, a more detailed stakeholder analysis is needed if decision-makers want to identify potential measures that could be undertaken in the future. This however was not part of the intended aim of the thesis, and as such, the risks and opportunities analysis here presents a foundation on which future projects and researches can build upon .

7.1.5 Data Collection

The aim of this research requires the collection and assimilation of a large quantity of information, ranging from data on environmental- and climate change to views and opinions of stakeholders.

a) Team work with other researchers

Firstly, this research is part of an overarching research topic proposed by the host-organization Living Lands. The actual field work was conducted by two students (myself and Amilcar Guzman), both with their own individual research topic. This entails the making of compromises, as information from interviews was used for two individual studies. Additionally, during the last month of field work, a third student joined the team (James Mulkerrins, a Wageningen University student specializing in framing and communication), also conducting his own individual research. It was deemed necessary to have three students work together in the area due to the aforementioned limitations regarding vehicles and availability of stakeholders. Naturally, aiming to accommodate three individual research topics in one interview is difficult and the overall quality of the obtained information may suffer as a result. Furthermore, due to the remoteness of the area that the researchers were based at, and the large distance to the study area, it was not possible to always be present in the study area. As such, meetings had to be mediated weeks in advance in some cases, and in other cases, a respondent was not available during a visit into the study area.

b) Interviews in the study area

Collecting information with the help of interviews can be both an advantage and a disadvantage. It is advantageous as it makes possible to obtain information from people that are directly affected by the various issues that were the subject for this thesis. Meeting stakeholders in person and having a semi-constructed interview often makes it possible to touch upon controversial issues that people might be reluctant to talk about on the phone or through email. On the other hand, answers obtained through the use of a questionnaire are often lacking a certain depth, as respondents may not be willing to answer to the intended level of detail. Furthermore, meeting with stakeholders in person often helps to build a positive relationship with the interviewee, which is helpful when sensitive topics are touched upon. The interviews were semi-constructed and this allows preparing topics and guiding an interviewee through the interview in an open-hearted way. Addressing controversial topics is then easier.

Nonetheless, the use of carrying out interviews also bears disadvantages. For one, the researcher is only able to obtain as much information as the respondent intends to share. Collecting detailed information on a controversial issue is extremely difficult if an interviewee is unwilling to share his opinion or if he perceives that there is no benefit for him in sharing his opinion. Ultimately, it is almost entirely up to the respondent to decide which issues he deems the most important, and on what topics he would like to spend the most time on. This however ensures that the research provides a realistic overview on which issues are approachable and easy to target, and which issues are more complex. Moreover, during an interview, a topic can be approached from different angles.

c) Timing of field research

All of the information that was obtained from stakeholders was gathered during the months of September to December 2014. While only marginally affecting the results, the seasonality and timeframe might still have a significant impact. The preceding two years have yielded good harvests, and climatic conditions have been favourable. This may have influenced the views of all stakeholder groups. Interviewees may potentially have been more optimistic towards the future than they would have been if the preceding years were not going well. Conversely, just one week after termination of this field work, a large hailstorm hit the Langkloof area and caused severe damages. Interviews following directly after this event may well have yielded different results.

d) Duration of field research

Perhaps the most important constraint for the data collection was time. While literature research could be done before and after the actual field work, it was only possible to collect data directly from the area during the three months of field research. As already mentioned, it was sometimes not possible to visit the study area for weeks, thus appointments could not be made with all intended individuals. Furthermore, due to the fact that not much research has been carried out in the Langkloof area previously, a large amount of time was spent on networking in the beginning. The researchers had to introduce themselves with most stakeholders before it was agreed to meet for an actual interview. This left less time for the actual conducting of interviews during the field research. Also, it was especially difficult to set up meetings during the end of October, as it was a busy period for the deciduous fruit farmer. This constraint became even more limiting, as the conducting of interviews is time-consuming. It is only possible to meet with a small number of interviewees on a given day, especially as the Langkloof area is quite vast, and most interviews took between 30 minutes and half an hour. Coupled with the fact that there was another researcher present (and in the final month, a third researcher), a large variety of themes and questions had to be covered during an interview. Furthermore, with the addition of a third researcher, interview questions had to be adjusted and this created a small difference in how interviews were conducted in the beginning when compared to how they were approached towards the end of the field work.

While the researchers were endeavouring to be able to obtain as much relevant information as deemed possible, sometimes a topic could only be discussed shortly in order to allow for a more in depth discussion on a different topic. However, at the same time, because other researchers were present during the meeting that pursued their own topics, it provided this research with a more holistic overview of the many issues in the Langkloof. This allowed a better understanding of the area as a whole.

e) Researcher / Nationality Bias

Another circumstance that needs to be mentioned is that this research was carried out by foreign students with a focus on environmental research. This may very well have created a certain impression on interviewees that could have led to a bias of their answers. Respondents may subconsciously have presented or shared information in a way that they thought they were expected to, rather than to openly and freely talk about their most pressing needs and own views. While great care was taken to avoid such a situation, it is not always possible to rule out a personal bias. Similarly, interviewees might have presented issues in a way that was favourable for them, even though the researchers verified statements against the information given from other respondents or against information provided from the literature.

f) Use of different sources of information

In order to collect as much information as possible and to complement the information gathered through interviews with local stakeholders, it was essential to conduct an extensive literature research. It was thus necessary to combine different data sources, which sometimes made it difficult to synthesize information in a coherent way, as the data provided by these different sources were not always consistent with each other. Some sources had conflicting information on topics or provided a different outlook on a certain issue, which complicated the interpretation of the data. Similarly, not many scientific reports that dealt specifically with the Langkloof were available. Most report treated a much larger area than just the valley or the Kouga catchment. In those cases it was difficult to assess to what extent the impacts that were discussed for could affect the Langkloof. Thus, sometimes information had to be omitted as no clear reference to the Langkloof was made.

Furthermore, data was collected from the GIS-records of the organisation Living Lands to obtain additional information on the spatial distribution of vegetation in the Langkloof. However, these records were not always complete and often not sourced, which made it impossible to use them in this research.

7.2 Discussion of Results

7.2.1 Environmental Impacts

The aim of the ecosystem service assessment method was to provide an overview of the various services, and address the benefits that local stakeholders obtain from said services. As a result, the information provided in chapter 4.2 is largely qualitative. While this may reduce the importance of the findings in some ways, it enables this research to adequately represent the use and subjective importance of ecosystem services for the various actors in the Langkloof. Quantitative data is difficult to collect and it is furthermore difficult to justify values in many cases. Furthermore, this research was created for the organization Living Lands, who have only recently started to work in the Langkloof, and as such, were primarily interested in receiving an overview of the relative importance of ecosystems and their services, but specifically not to quantify them, as this would have required a singular focus on this issue and a longer time in the study area. Due to the nature of qualitative information, the results of the IEA are of a subjective nature and should be treated with caution. Nevertheless, wherever possible and available, quantitative data was included in this research.

Despite the great use of breaking down the complexity of an environmental system into different ecosystem services and their benefits, it is still only an attempt to represent an ecosystem in terms that are definable and comprehensible to people. This research followed the TEEB typology, consisting of Provisioning, Regulating, Cultural and Habitat services. This however is not the only typology, and there exist others (e.g. MA, 2005) that might have led to slightly different results. Furthermore, the identification of trends in the supply and demand of ecosystems services was largely based on stakeholder information and perception (although literature data and observations were applied as well). While this ensures that local knowledge is adequately represented, it also may lead to uncertainties, as interviewed stakeholders may not always possess an in-depth knowledge about the functions of nature. Hence, to avoid presenting unreliable results, interviewees were often presented with follow-up question if an answer was deemed to be unreliable or unjustified. Moreover, certain comments and views were often brought up during other interviewees and allowed determining if a concern that was voiced by a stakeholder was indeed an issue or only felt by him.

7.2.2 Social Impacts

In total, 29 interviews with various stakeholders were carried out during this field research. While this may initially seem like a relatively small number given the large size of the area, the number of possible interviews was restricted due to logistics and time constraints. Furthermore, the research took great care to identify and select the most important actors. From the agricultural sector, the largest and most influential farmers were chosen from a variety of settlements in the area. A number of employees of the municipality were interviewed to include local government actors, whose task it is to deal with local issues on a daily basis. Additionally, representatives of different government departments were contacted to include also regional decision-makers, and to obtain a broader perspective on various issues. Finally, experts were chosen as part of the interviewed stakeholder group for their neutrality and great knowledge on a variety of subjects. As such, while the total amount of interviews may seem small at first, it reflects a synthesis of the views and opinions of the most important and knowledgeable actors in the area. The approach that was followed in this stakeholder analysis was that of a "grounded theory". This theory is a popular tool to amass and assess qualitative information (Punch, 2014). With it, a certain view is constructed by the researcher through an iterative process of collecting information from stakeholders, until the dataset is complete, that is, until no new viewpoints emerge in an interview. This point was reached, and as such, the opinions and views constructed in Chapter 6.4 are robust in so far as that they are based on the common perceptions and views of the most important stakeholders.

7.2.3 Uncertainties

As was already touched upon, this thesis did not primarily aim to provide detailed, quantitative information on a number of issues, but rather attempted to reflect the views, relationships, and opinions of stakeholders, and in what way they are currently or potentially affected by social and environmental issues. As such, the nature of this thesis is qualitative more so than quantitative. This naturally creates a shade of uncertainty in the here provided discussions and results. The relatively small sample size of interviews is perhaps the major source of uncertainty in this research. Due to constraints regarding time, logistics, schedules, language and local willingness, it was not feasible to collect interviews from more stakeholders (i.e. other government departments, black emerging farmers, citizens, …). Thus, a portion of the data discussed and analysed here stemmed from third parties, that is, from stakeholders that proved to have extensive knowledge about a certain topic, and that were thus questioned about that topic. Nevertheless, as the sample size is small and it was not possible to receive an interview from all contacted stakeholders, a certain degree of uncertainty remained. This uncertainty was kept at a minimum by using the aforementioned "grounded theory". Only after a perceived issue had been stated multiple times and after a clear picture had been formed was it included in this analysis. Opinions that were deemed to be unreliable were not included in this research.

Another source of uncertainty is the form of information that was collected, which was largely subjective. Interviews, while having many advantages as already mentioned, also have drawbacks, such as biased answers. Respondents may want to stress the importance of issues that are of particular interest to them, and may slightly distort other issues. For this reason, statements were often confirmed through neutral experts in order to reduce uncertainties and unreliability. Including experts was especially important as more fruit farmers were interviewed than other stakeholder groups to better accommodate for another researcher's focus in whose research fruit farmers were the primary target group.

Moreover, as is the case with all climate projections, it is extremely difficult to correctly predict trends in climate, especially as far as quantitative data is concerned. Therefore, this thesis included as much information from the literature as possible on the subject to corroborate statements. Firstly, records on climate data in South Africa, especially for a remote region such as the Langkloof, were scarce. Thus, in some occurrences, data was used that had a larger resolution than needed. Secondly, despite a general accord in the literature, there also existed contradictory information (e.g. an increase vs decrease of rainfall). While this also creates uncertainty, information was only included when there was a general agreement in the literature or amongst the stakeholders.

8 Conclusions

8.1 RQ-1 – State, Conditions and Trends in Ecosystem Services

The first research question addressed the state of ecosystems and their services in the Langkloof, as well as their various benefits for the area and what the main environmental issues are. Based on the ecosystem service analysis, it became clear that the provision of food and fresh water were the most important provisioning services in the Langkloof. Water is and will be vital in order to sustain an ever-growing population and the agricultural production. It is this production of fruits that is the lifeline of the Langkloof. Without agriculture, the economic relevance of the region would disappear, employment would decrease, and poverty would rise. It is also for this reason that regulating services such as climate and water quality regulation, moderation of extreme events and the maintenance of nutrient cycling and soil fertility are of crucial importance. These services make up the foundation that is necessary for successful and sustainable agriculture. It is therefore highly concerning that the availability of water is threatened due to increasing environmental degradation, inadequate storage facilities and a more intensive use of water, endangering the prosperity of the entire Langkloof. The main environmental issues, as identified through stakeholder interviews, are deemed to be a conflict and shortage of water, the occurrence of extreme weather events, a growing infestation of natural vegetation by invasive alien plant species and a future change in climate.

8.2 RQ-2 – Current and Future Impacts of Climate Change

The second research question aimed at examining the current and future impacts of climate change. While the climate at present is very suitable to the growing of deciduous fruits, this might change in the future. Based on the climate change analysis, it became apparent that temperatures are likely to rise by at least 1.5 to 2.5°C within the coming 40 to 50 years. Consequently, the number of days with extremely high temperatures is rising and nights with freezing temperatures will become fewer. Whilst rainfall is projected to increase in most models, it is likely that this increase will take place during the rainy season, thus further increasing the risk of intense rain events. Altogether, the climate will almost certainly become more variable and less stable, resulting in a more frequent occurrence of extreme weather events. It is also expected that climate change will contribute to a faster-spreading of diseases such as malaria, and in general reduce human health in the area. It needs to be mentioned though that is a considerable degree of uncertainty when addressing future projections of climatic changes.

8.3 RQ-3 – Risks of Environmental Change

Research question 3 examined the risks of possible changes in ecosystem services for stakeholders in the Langkloof. As discussed in chapter 6, most stakeholders would be negatively affected by a change in ecosystem services, if current trends continue. As discussed in chapter 4, according to a majority of the interviewees (22 out of 29 agreed on this), the demands for important ecosystem services (e.g. water, food, climate and water regulation, erosion control, moderation of extreme events, biological control, nutrient cycling and soil fertility, and ecotourism) will rise in the future. Simultaneously, the supply of most of these services will likely decrease. Extreme weather events and a shortage of water affect all stakeholders equally, as droughts, floods and hailstorms will become more frequent, and water-driven conflicts become more common. Fruit farmers are especially affected by a decline in those services that are essential for the growing of deciduous fruit, such as biological control, soil fertility.

8.4 RQ-4 – Needs and Interest of Stakeholders and Social Issues

The two major stakeholder groups in the Langkloof are the fruit farmers on the one hand, and the various government departments and the municipality, who represents the needs of the common people, on the other hand. Both stakeholder groups stated their need for more water security. In addition, the fruit farmers want to increase their production for which they require better water storage facilities, new technologies and fruit varieties, and less pressure from the government. The governmental representatives, on the other hand, aim at improving living conditions and infrastructure in the Langkloof, for which they stress the importance of better cooperation from fruit farmers.

8.5 RQ-5 – Analysis of Conflicts and Synergies among Stakeholders

During the field research it became clear that relations were strained. Stakeholders accused each other of a lack of understanding and cooperation, and there is a general mistrust between the fruit farmers and the municipality or government departments. Concerning environmental issues, all stakeholders were equally concerned about the future supply of water, but fruit farmers showed themselves to be more concerned about environmental and climatic change than the government representatives, as these changes would threaten agricultural activity. Not surprisingly then, the municipality was much more concerned with social issues such as poverty, working conditions, supply of electricity, infrastructure and living conditions, as these are all acute problems among a majority of the Langkloof population.

8.6 RQ-6 – Opportunities for Adaptation to Environmental Risks

The main environmental risks in the Langkloof are a shortage of water and the impacts of climate change in the future. Possible adaptations to a shortage of water mentioned by the stakeholders include the building of additional storage facilities, the reparation of old and outdated infrastructure, the conservation and restoration of nature, the eradication of IAPs and a much-needed cooperation amongst stakeholders in regards to collaboratively finding solutions (e.g. by joining a collective water forum that is currently being drawn up).

Concerning the impacts of future climate change, adaptation options mentioned by stakeholders and found in the literature consist of a better monitoring and researching and the construction of additional storage facilities to better deal with droughts or water shortages in the future. Especially fruit farmers can better adapt to climate change by developing new varieties that are more suited to warmer temperatures, and by reducing their impact on the environment by using less chemicals.

8.7 Reflection on the Overall Aim of this Thesis

The overarching objective of this thesis was to provide a first and thorough overview of the Langkloof area, its stakeholders, the state of its ecosystem and ecosystem services, its social issues and its vulnerability to environmental, social and/or climatic change. In order to compile and analyse data related to these different aspects, as much relevant data as possible was collected through interviews with municipality representatives, fruit farmers and government officials. In addition, stakeholder meetings have been attended and local experts were consulted. Furthermore, quantitative data from the interviews, data on climate and vegetation, and other environmental aspects have been included wherever sensible and possible. Nevertheless, due to the remoteness of the study area, the limited number of visits to the area, and the lack of previous work, it was difficult to find 'hard' data and the results necessarily are largely qualitative.

However, the primary goal of this thesis was to obtain a detailed overview of the ongoing and future changes in the Langkloof. This has successfully been achieved and I hop that the information provided in this thesis will be useful for Living Lands and other actors who want to facilitate or participate in social or environmental development of the Langkloof.

9 Recommendations

9.1 Risks and Opportunities

This section aims to summarize opportunities for adaptation to the different risks and issues that were identified in chapters 4, 5 and 6. As these issues have already been discussed in greater detail in the corresponding section, it is the aim of this section to focus on different adaptation options to these problems that are available to the stakeholders in the Langkloof. Moreover, on request of the NGO Living Lands, who have facilitated this research, recommendations on how the organization could possibly proceed in the Langkloof are also included in this section. This section will not address each individual issue that was identified, but will focus on the main issues. Based on the ecosystem service analysis, the climate change analysis and the stakeholder analysis, a shortage of water in the future, an increase of average temperatures, and greater weather variability were deemed as most crucial by the researchers and the stakeholders themselves. Thus, this section will aim to mention a number of adaptation options to these issues. It has to be noted that social issues were at least as important as the mentioned environmental issues. However, these issues, such as labour problems, mistrust and communication problems have all already been extensively addressed, and there are no "miracle" adaptations available to overcome these issues. As far as a lack of cooperation is concerned, it is essential that stakeholders realize that they will not be able to solve future problems all on their own. Participating in collaborative efforts is necessary for all stakeholders.

9.1.1 Opportunities for Adaptation to a Shortage of Water in the Future

Considering the future supply of ecosystem services, the supply of fresh water has been identified as the most crucial service (see chapters 4.2 and 6.4.2). Furthermore, the future supply of water is severely threatened by a decreased vegetation cover, a spreading of IAPs and a more intensive water use by people and agriculture.

For the Koukamma municipality and the different government departments, there are a number of opportunities for adaptation that should be considered. The building of new and additional (communal) dams and the replacement or reparation of old, inadequate infrastructure is perhaps the most needed and simplest adaptation, as current water storage facilities have been identified as insufficient. Moreover, the conservation and restoration of native vegetation, alongside a more efficient eradication of IAPs is another measure that would help strengthen the natural supply of fresh water. The efforts of the Working for Water program need to be more efficient, as there is still a spreading of IAPs in the area despite the efforts of the team. Follow-up measures need to take place more often and the cleared material needs to be transported away from the area to reduce the risk of clogging the river channels. More emphasis should be placed on attempting to fully clear upstream areas, especially in the mountains, as seeds can easily be transported downstream and lead to a regrowth of cleared areas. Also, sensitive areas such as floodplains and wetlands should be conserved and restored. Additionally, the government should ideally provide additional financial support to emerging black farmers, as many still lack the financial resources to use the most water efficient irrigation and farming techniques. Finally, it is advised that the municipality and at least the Department of Agriculture, Department of Environmental Affairs and Department of Water Affairs and Sanitation are participating in a Langkloof-wide collective water forum to better facilitate an exchange of information and an identification of collaborative solutions. Such a water forum is currently being drawn up by the NGO Living Lands, who are looking to organize and chair the meeting in the near future, if support from the stakeholders in the Langkloof is present.

The deciduous fruit farmers have proven to possess an extensive knowledge on nature and its services. As such, nearly all commercial fruit farmers use the most sophisticated irrigation techniques and are often monitoring pests, soil quality and pollinators. Hence, fruit farmers have already adapted well to the relative scarcity of water. Despite this, there are still a few additional options that are available to fruit farmers when faced with a shortage of water in the future. The use of mulch to enhance the water retention ability of the soil could be applied more extensively. Furthermore, there is a potential to use IAPs as material for mulching. While most fruit farmers clear IAPs on their own land, it could be more beneficial for them to collaborate more closely with the WfW program. Due to the limited budget of the WfW program to adequately clear difficult-to-access areas such as mountains, these source areas are not cleared entirely. By only clearing IAPs on their own land, they are vulnerable to a renewed invasion of IAPs, as seeds get dispersed from the mountains and the upstream areas. Thus, it would be in the interest of fruit farmers to support the WfW program and to help clear IAPs not only on their own land, but also on the mountain slopes. Furthermore, the fruit farmers should also join the collective water forum and cooperate with the municipality and the government. Currently, the two sides are competing more so than cooperating as far as water use is concerned. Better communication is needed if the water issues are to be solved in the future and supporting and joining the Langkloof water forum would be a step in the right direction.

The NGO Living Lands should continue to aim to bring the various stakeholders together. More specifically, the Langkloof water forum is a great opportunity to do so. The forum could serve as a key institution to successfully address and solve issues around water. During the field research, almost all interviewees proved to be interested in a collective water forum. Thus, as a willingness to cooperate is present amongst the stakeholders, Living Lands are now required to fulfil the role of a mediator between the government, the municipality and the fruit farmers in order to create. Hence, relations should be built and an initial meeting set up as soon as feasible to ensure support amongst the stakeholders. It is also essential that Living Lands set up a base of operations within the Langkloof area, which is not yet the case. Living Lands ought to devote as much time and effort as possible to facilitate a Langkloof water forum. Besides that, Living Lands should become active in efforts and projects to restore and conserve nature in the valley. The present day situation in the Langkloof presents an excellent opportunity for the organization to contribute to a more sustainable management of the Langkloof valley, and as such, there is the potential for Living Lands to successfully operate in the area.

9.1.2 Opportunities for Adaptation to Climate Change

The potential impacts of climate change have been addressed already in chapter 5. Most importantly, temperatures will rise, as will climatic variability. While average rainfall is projected to increase slightly, it will mainly do so during the rainy season. Thus, there is a possibility that intense rainfall events will take place more often. Also, droughts are still very much a possibility in the future, as climatic variability increases, and so long droughts can still happen. Essentially, the frequency of extreme weather events such as hail, floods and droughts will only increase in the future. Coupled with an almost certain increase in temperature, this poses a number of challenges for the Langkloof.

Although adaptation options to climate change are limited for the municipality and the government departments, there are a number of strategies that can be carried out to better prepare for climate change. So far, almost all interviewed governmental actors indicated that climate change and the effects thereof are not taken into account or addressed in many management plans and projects. While there are national strategies to adapt to climate change (DEA 2013a and b; DEA & DP, 2008, Johnston *et al.*, 2011), there is relatively little progress being made on a local scale. As climate change directly ties into the availability of water in the future due to a rise in temperatures and a change in rainfall, an important adaptation will be to improve the infrastructure. This includes the building of new storage facilities, but also relates to repairing and improving existing infrastructure. Another opportunity for better adapting to climate change would be to conserve nature and its functions in order to reduce climate vulnerability and increase climate resilience. An increased use of renewable energies and a reduction of the carbon footprint could also help to indirectly enable better adaptation to climate change, by mitigating its effects beforehand (DEADP, 2008).

There are a number of climate-related adaptation opportunities available for the deciduous fruit farming industry. As previously indicated, an increase in temperature could reduce the amount of days with frost in winter, which might reduce the productivity of certain fruits, such as apples. To counter that, as was also stated by various fruit farmers (DFF 1, 2, 7, 9, 10) new varieties would be an option. The planting of fruit varieties that need less cold units and would therefore be better adapted to a warmer climate could be a successful measure. However, as there are many uncertainties related to the productivity and marketable value of new varieties, extensive and focused research of new varieties would be necessary before the introduction of new varieties. While the use of additional water for irrigation would help to counteract an increase in temperature, this is not a feasible option in the Langkloof, as water is scarce. But the addition of new farming dams would be an option to increase the storage potential of each fruit farmer. This has also been indicated by the farmers themselves, but currently the government is prohibiting the building of private dams in order to ensure that downstream users receive enough water (DFF 10). Switching to more environmentally friendly chemicals or to organic fertilizers would also increase the resilience of the vegetation towards climate change. A potential increase in the frequency of extreme weather events has serious repercussions for fruit farmers. Despite that, there are few adaptation options available. Many fruit farmers are (at least partially) insured, but due to insurance premiums rising in recent years, many fruit farmers opt to live with the risks. Furthermore, not all fruit farmers are financially able to take out insurance, and are thus forced to live with the risk of natural disasters. Hence, insurance is likely not going to be the single solution to extreme events. In terms of adapting to droughts, once again, the building of additional water storage infrastructure would help to alleviate the water scarcity in times of droughts. But the most important and devastating weather occurrence in the Langkloof is hail. Aside from insurance, a potential adaptation to these events would be the instalment of hail nets. Such nets could help to decrease the damage from hailstorms.

Living Lands have the excellent possibility to contribute to a better adaptation to climate change by facilitating research in the area that specifically aims to investigate different adaptation strategies to climate change. Living Lands could thus provide the scientific basis for different adaptation strategies in the Langkloof. In order to do this, Living Lands should aim to obtain direct support from the government, so that students have the possibility to cooperate and work together with the government on a specific climate-related issue or adaptation strategy.

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Appendix

1 Appendix I – Detailed overview of the study area

1.1 Climatic Conditions

Despite the fact that South Africa is situated between the 22°S and 35°S latitudes, and therefore falls within the Southern Hemisphere's subtropical zone, its average temperatures throughout the year are comparatively lower than those of other regions of similar latitude. A reason for that is the high elevation of South Africa's landscape. Summer in South Africa begins in October and ends in March, with highest temperatures usually in January and February. Temperatures in summer generally vary between 15 degrees at night and up to 35 degrees in the early afternoon, although more extreme temperatures are also possible (Kruger and Shongwe, 2004). Winter starts in April and lasts until September, with July and August being the coldest months of the year. Lowest temperatures are ordinarily around 0 degrees at night and up to 20 degrees during the day (Official weather reports). Annual rainfall in South Africa is around 460 mm, which compared to the global average of 860 mm, defines the country as semi-arid according to the Köppen climate classification. Timing and amount of rainfall is also highly variable, both in terms of spatial and temporal variation, although in most areas of South Africa, most of the rain falls during the summer when the Inter-Tropical Convergence Zone (ITCZ) moves southwards (Jury, 2002). However, not only rainfall is highly variable in South Africa, also the climate itself is heterogeneous. This is largely due to the influence of the Indian Ocean to the east and the Atlantic Ocean to the west (Walker, 1990). Thus, South Africa is situated between high pressure zones in the east and the west. Depending on the prevailing global winds, the weather in each region is therefore subjected to large inter-annual variations, which is the reason for South Africa's very diverse climates and explains why the country is frequently experiencing periods of severe droughts or heavy rainfall. The Agulhas current of the Indian Ocean transports warm water and humid air along the eastern coast of the country and thus leads to a humid and warm climate, whereas cold water of the Benguela current from the Atlantic Ocean flows northwards along the western coastline of South Africa and causes drier conditions (Walker, 1990). As a result, temperatures and humidity differ between the western and the eastern parts of the country.

The Eastern Cape measures an annual rainfall of 550 to 700 mm, which is therefore higher than in most other parts of South Africa (Blignaut *et al.*, 2009). The Langkloof itself experiences large variations in rainfall even within the valley. The settlements of Haarlem and Avontuur to the west receive approximately 800 mm of rain per year, whereas only around 300 mm of rain fall annually near the eastern border of the valley in The Heights (Haigh *et al.*, 2004). Rainfall records stemming from Joubertina place the annual rainfall at 476 mm (Sam van der Merwe, 2014, personal communication). Overall, the average annual rainfall in the valley is around 500 to 550 mm, which is above the South African average (DWAF, 2009). Another characteristic of the study area is that it experiences a bimodal rainfall pattern (Cowling and Pierce 2009; Mander *et al.* 2010). Hence, most of the rain falls in autumn or spring, whereas most other regions in South Africa, with the exception of the Western Cape, receive the majority of rainfall in summer. According to the Köppen classification, the climate in the Langkloof can be described as a mild Mediterranean climate.

Summers in the Langkloof are warm and dry, and temperatures above 40°C can be recorded occasionally. Average daily sunshine is around 7 to 8 hours (official weather stations). Another reason apart from the influences of the Indian Ocean and the prevailing global winds for the variability in climate within the Langkloof valley is its topography. The Tsitsikamma Mountains in the south and the Kouga Mountains in the north each influence the wind patterns and can act as a trap for rain clouds from the ocean (Sandbrink, 2013). Average midday temperatures in summer are around 25 degrees and around 16 – 18 degrees in winter, highlighting the mild climatic conditions in the Langkloof valley. Snow can be found on higher altitudes in the Langkloof in winter, and the valley also commonly experiences frost days (van der Merwe *et al.*, 1991; Haigh *et al.*, 2004), which can pose risks for the local agriculture.

Overall, the climate in the Langkloof makes it very suitable for the growing of deciduous fruits.

1.2 Biophysiscal Structure of the Landscape

This chapter will discuss the most prominent biophysical structures of the Langkloof. The geologic formation of the landscape and its significance for flora and fauna will be addressed, as well as the composition of the soil and the hydrology of the area. The aim is to give the reader a good foundation of the underlying geologic and biologic history, in order to better understand aspects of the later discussed findings.

1.2.1 Geology and Geomorphology

The geology of South Africa is quite old compared to many other countries on Earth. What is known today as South Africa used to be a part of the former supercontinent Gondwana. The supercontinent Gondwana formed already during the beginning of the Cambrian (~850 million years ago) and was completed well into the Ordovician (approximately 570 to 510 million years ago) (Meert and Van der Voo, 1997). However, even older rocks, dated at 3,700 million years ago can be found in South Africa today (Kröner *et al.*, 1996). These are some of the oldest rocks still found today on Earth and highlight South Africa's long geologic history. Eventually, Gondwana joined with another supercontinent called Laurasia to build a third, and larger supercontinent: Pangaea. After Pangaea started to break up in the Early-Middle Jurassic period 175 million years ago, the former continent of Gondwana also started to break up and was subjected to a range of long-lasting geologic processes, such as tectonic rifting, the formation of crevasses, volcanic activity, erosion and rocks deposition. The next

10 - 25 million years of geologic activity have shaped the land and turned it into the rugged and highly elevated landscape that can be observed in present-day South Africa. Large deposits of gold, diamond and ore, amongst others, have resulted in a rich mining history in South Africa. Because of the hard rock geology in South Africa, groundwater availability is limited and highlights the importance of surface water as a primary water source (Calzadilla *et al.*, 2014).

The Langkloof is embedded between the Kouga Mountains to the north and the Tsitsikamma Mountains to the South and was formed during an uplifting event around 20 million years ago (Cowling and Pierce, 2009). The valley itself is situated roughly 300 meters above sea level and contains relatively nutrient rich soils due to the local geology, although a large portion of the land has been degraded (Sandbrink, 2013). The Kouga Mountains are higher and reach their highest point on top of the Hoosberg at an elevation of 1,705 meters, whereas the highest point of the Tsitsikamma Mountains is at an elevation of 1,500 meters above sea level. Both are part of the much larger complex of the Cape Fold Belt, which formed during the late Palaeozoic approximately 300 to 250 million years ago (Shone and Booth, 2005). This fold and thrust belt covers most of the southern parts of South Africa and is heavily folded and deformed (Du Toit and Haughton, 1954). Generally, most of the area around the Langkloof is dominated by quarzitic sandstones of the Table Mountain Group. However, approximately 400 million years ago, during the Devonian period, fine-grained sediments of the Bokkeveld shale formation were deposited in the area, containing mainly mudstones. This group survived in the valley of the Langkloof, although it has been eroded from the surrounding mountaintops (McCarthy and Rubidge, 2005).

1.2.2 Soil Composition and Hydrology

The mountainsides surrounding the Langkloof valley are demarcated by acidic, nutrient poor and dry soils. However, the soft mudstones of the Bokkeveld group in the valley itself form very fertile soils due to their larger capacity to retain water and clay minerals (McCarthy and Rubidge, 2005). The soil in the Langkloof is generally fertile as it contains a high amount of clay and nutrients, which are derived from the shales of the Bokkeveld group (Veerkamp, 2013). This is one of the main reasons for the extensive agriculture in the Langkloof.

The hydrology around the Langkloof is of vital importance to the valley for its agriculture and human use, but it plays a far bigger role for the whole of the Eastern Cape. As previously stated, the Langkloof valley is part of the Kouga catchment. The mountains around the Kouga catchment act as a water trap, and transport water from the mountains down into the valley into the rivers. The largest of those is the Kouga River, which also drains the catchment. It flows eastwards through the Langkloof valley, during which it is joined by smaller tributaries. Eventually it turns northwards, where it flows in between the Kouga and Suuranys Mountains. Finally, the Kouga River is joined by the Baviaanskloof River and afterwards ends in the Kouga dam, where the water is being accumulated. From there, the Kouga River joins the Groot River to form the Gamtoos River, which flows southwards towards the ocean.

Due to the already mentioned low rainfall in South Africa and the limited groundwater resources, the Kouga catchment is of vital importance for the Eastern Cape, as South Africa is highly dependent on its catchments for water. Ultimately, the Kouga catchment, through its accumulation of water, not only supplies the largest share of water resources for the Langkloof, but also for many regions located downstream. The Gamtoos valley and its settlements obtain their water from the Gamtoos River, which is fed by the Kouga River. Also, the Nelson Mandela Bay Metropolitan region, of which the city of Port Elizabeth is a part of, receive the majority of their water from the Kouga catchment and the Kouga River.

Wetlands have also formed in many occasions in the Langkloof valley and in the neighbouring Kromme catchment, although the wetlands in the area have been largely converted by humans for other purposes (Haigh *et al.*, 2004). Due to the fact that groundwater resources are limited, rainfall plays a crucial role in upholding the water supply of the Kouga catchment. It is for this reason that the variability in rainfall and future climate change can cause great problems for the whole of the Eastern Cape, as many different regions are depending on these water resources.

1.3 Vegetation

One of the main reasons for the high bio-diversity in South Africa is the existence of different vegetation biomes. Approximately 20,000 plant species can be found in South Africa (SANBI, 2014), which accounts approximately for 5 – 10 % of all estimated plant species on Earth (Scotland and Wortley, 2003; Ungricht, 2004). Almost half of the plant species in the country (roughly 9,000) are found around the southern tip of South Africa, in the Eastern and Western Cape, with approximately 70 % of its flora being endemic to the area (Goldblatt, 1997; Goldblatt and Manning, 2002). This area is called the Cape Floristic Region (CFR) and its floristic particularities (e.g. endemism and richness) denote it as a unique floral kingdom (Meadows and Sugden, 1993; Low and Rebelo, 1996; Goldblatt, 1997). As such, the CFR comprises nearly 20 % of the African continent's flora in approximately 5 % of its surface (Goldblatt and Manning, 2002), it is deemed as one of the world's biodiversity hotspots (Myers *et al.*, 2000) and recognised by UNESCO as a World Heritage Site. The CFR extends eastwards from the south-western tip of the country into the Eastern Cape and encompasses Mediterranean-climate dominated areas, as well as a broad diversity of landscapes that include different biomes and vegetation types (Goldblatt and Manning, 2002).

The currently accepted classification of South African vegetation comprises 9 biomes (Mucina and Rutherford, 2006), from which 6 are represented in the CFR. Based on the spatial analysis of the vegetation map provided by Mucina and Rutherford (2006), one azonal vegetation type and 3 biomes are found in the Kouga catchment. Fynbos is by far the dominant biome in the area (93 % of the catchment), followed by Albany Thicket (6.6 % of the catchment) and Forest (0.03 % of the catchment) (*Table 7* and *Figure 17*).

***Table 7*. Main biomes, bioregions and vegetation types in the study area**

Biome – Bioregion – Vegetation type	**Area (ha) Kouga catchment**	**% (Kouga catchment area)**	**Area (ha) in the Langkloof[1]**	**% (Langkloof area)**
Fynbos Biome				
Eastern Fynbos-Renosterveld Bioregion				
Kouga Grassy Sandstone Fynbos	116,710	41.3 %	11,802	28.0 %
Kouga Sandstone Fynbos	96,025	34.0 %	909	2.2 %
Tsitsikamma Sandstone Fynbos	38,779	13.7 %	23,576	56.0 %
Eastern Inland Shale Band Vegetation	5,454	1.9 %	703	1.7 %
Eastern Coastal Shale Band Vegetation	1,787	0.6 %	1,291	3.1 %
Langkloof Shale Renosterveld	4,265	1.5 %	3,813	9.1 %
Albany Thicket Biome				
Albany Thicket				
Groot Thicket	14,984	5.3 %	-	-
Gamtoos Thicket	3,715	1.3 %	-	-
Azonal Vegetation				
Alluvial Vegetation				
Albany Alluvial Vegetation	497	0.2 %	-	-
Forests				
Zonal & Intrazonal Forests				
Southern Afrotemperate Forest	88	0.03 %	-	-
Total	282,303	100 %	42,094	100 %
[1] Based on the Langkloof's area estimated for this thesis				

Source: based on spatial analysis of the vegetation map provided in Mucina and Rutherford (2006).

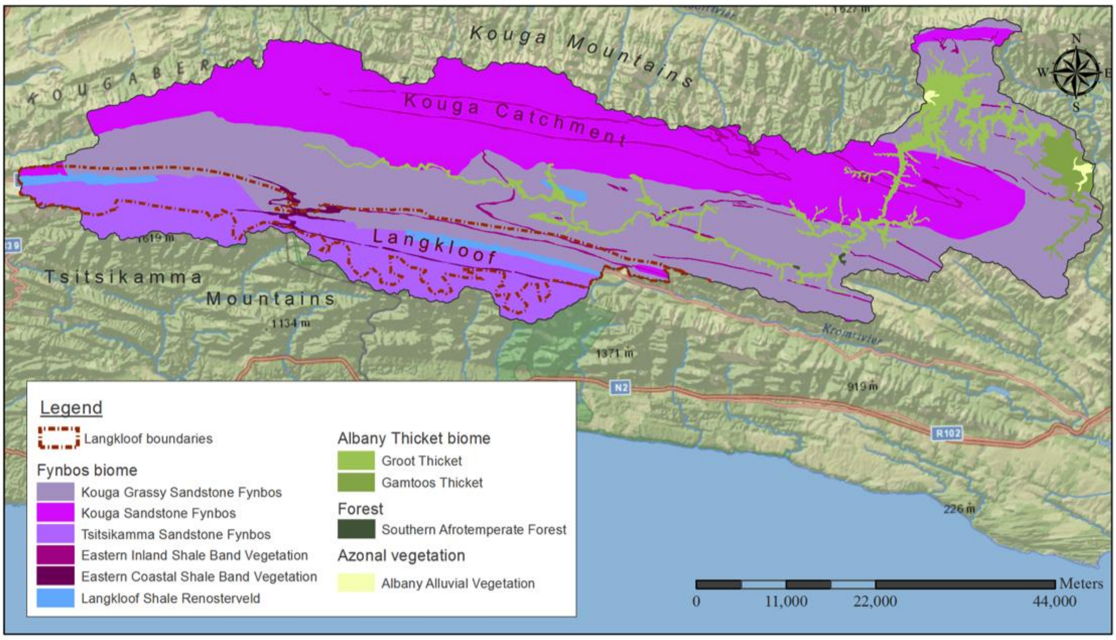

Figure 17. **Vegetation types in the study area (Mucina and Rutherford, 2006)**

In addition to the abovementioned vegetation types, wetlands represent another form of azonal vegetation, which has been largely modified by human activities in the area. The wetlands identified in the catchment include remnants of palmiet wetlands in the eastern part of the Langkloof and the Tsitsikamma Mountains, as well as seeps occurring in riparian and occasional floodplains in the Kouga Mountains (Haigh *et al.* 2004).

In order to provide a more specific idea of the most prominent features of the landscape in terms of vegetation, the following sub sections present the main characteristics of Fynbos and Albany Thicket, since both biomes together extend over more than 99 % of the catchment's surface.

a) Fynbos biome:

Fynbos biome refers to two main vegetation groups, Fynbos and Renosterveld, and it is generally characterized by high plant species richness and high numbers of endemic species in relatively confined areas or centres of endemism (Low and Rebelo, 1996; Ojeda *et al.*, 2001). Despite representing less than 7 % of the country's total area, according to national statistics for South Africa (SANBI, 2014), Fynbos is the biome with the highest number of threatened taxa (approximately 1,800 taxa) and the highest number of endemic taxa of conservation concern at the national level (around 3,150 taxa).

Poor and well-leached soils, such as sandstones, granites and shale, serve as a support for Fynbos vegetation, whereas more fertile fine-grained soils sustain the Renosterveld type (Rebelo and Siegfried, 1990; Low and Rebelo, 1996). These soil aspects are characteristic of the surrounding Tsitsikamma and Kouga Mountains, which explains why the majority of the mountains and its slopes in the Kouga catchment are covered with Fynbos vegetation (Veerkamp, 2013).

The Fynbos is a sclerophyllous shrubland (Cowling, 1992) composed by three main categories of plants, shrubby grasses on nutrient-poor soils with winter rainfall (e.g. Restionaceae), a majority of plants with small leaves with thick-walled cells on the upper surface and hairs on the lower surface (e.g. Ericaceae, Asteraceae, Fabaceae, etc.), and a final group of broad leaves plants (e.g. Protaceae). On the other hand, Renosterbos (*Dicerothamnus rhinocerotis*) dominates the Renosterveld type, along with other species, which also belong to the Asteraceae Family (Low and Rebelo, 1996).

Fires are important events for Fynbos plant communities' development and establishment (Low and Rebelo, 1996; Bond *et al.*, 2003; van Wilgen, 2009). Since many of the species in Fynbos regenerate from seeds after fires (Low and Rebelo, 1996), the frequency of fires necessary to sustain the community has been estimated at a minimum of 10 years and a maximum of 45 years (Low and Rebelo, 1996; van Wilgen, 2009). For this reason, prescribed burning, conducted in the right season (e.g. late summer) and frequency, is currently regarded as an effective management strategy for the vegetation types in this biome (van Wilgen, 2009; GOV 3) in order to avoid the invasion of other vegetation elements (e.g. alien plants or Thicket species) (Low and Rebelo, 1996).

The Kouga catchment is almost entirely classified within this biome (93 % of its area) and the entire Langkloof is part of it. The Kouga Grassy Sandstone Fynbos is the best represented vegetation type in the Kouga catchment (41 % of its area) and it covers 28 % of the Langkloof area (*Table 7*). This type is situated in the lower slopes of the Kouga Mountains (*Figure 17*) on acidic lithosol soils derived from sandstones in areas with mean annual precipitation of approximately 540 mm. It is described as a low shrubland with sparse, emergent tall shrubs (e.g. *Aspalathus kougaensis*, *A. nivea*, *Dodonaea viscosa* var. *angustifolia*) and succulent shrubs species (e.g. *Aloe ferox*) (Mucina and Rutherford, 2006)

Kouga Sandstone Fynbos is the second best represented type in the area (34 % of the catchment), although it only covers approximately 2 % of the Langkloof (*Table 7*). This specific type extends along the Kouga Mountains at higher altitudes than the Grassy Sandstone Fynbos, as well as in a confined band next to the lower Langkloof (towards the eastern portion of the valley in the study area) on southern slopes of the Suuranysberg (*Figure 17*). This type occurs in acidic lithosol derived from sandstone areas, where the mean annual precipitation reaches around 600 mm. It includes low Fynbos in high altitudes, as well as Protaceae tall shrubs in intermediate slopes (Mucina and Rutherford, 2006).

Despite of covering roughly 14 % of the catchment, the Tsitsikamma Sandstone Fynbos covers more than half of the Langkloof's surface (56 %) (*Table 7*). This is due to its distribution over low altitude coastal mountains with moderately undulating plains that neighbour the valley to the south (*Figure 17*). Occurring on acidic soils from Ordovician sandstones and in areas with a mean annual precipitation of approximately 850 mm, this vegetation type is described as a medium dense, tall shrubland (e.g. *Leucadendron conicum* and *L. eucalyptifolium*), over a dense lower shrubland (e.g. *Erica discolor* var. *speciosa*, *E. sparsa* and *Ursinia scariosa* subsp. *scariosa*), which mixes with Fynbos thicket in wetter areas (e.g. *Pterocelastrus tricuspidatus*) (Mucina and Rutherford, 2006).

The Eastern Inland Shale Band Vegetation, Eastern Coastal Band Vegetation and the Langkloof Shale Renosterveld cover, altogether, only 4 % of the Kouga catchment. Nevertheless, the latter type is almost entirely represented in the Langkloof, where it covers approximately 10 % of its area (*Table 7*). The Langkloof Shale Renosterveld occurs over a narrow distribution in localized areas with clays and loams derived from shales at lower slopes with mean annual precipitation of around 500 mm (*Figure 17*). As indicated in the type classification it is dominated by renosterbos in a shrubland with cuppressoid-leaved species and a stratum of gaminoid species (Mucina and Rutherford, 2006).

Most of the vegetation types mentioned for the Fynbos biome have been largely affected by a widespread occurrence of invasive alien plant species (IAPs) in the Kouga catchment and the Langkloof, which is further explained in section 1.7 of this chapter.

b) Albany Thicket Biome

The Albany Thicket biome is characterized for its types that are usually understood as transitional ones, since many of their floristic components are shared with other biomes. In general terms, it can be described as a dense thorny shrubland or low forest with little herbaceous cover that includes dominant evergreen and sclerophyllous elements, as well as high covers of succulent shrubs and trees (Low and Rebelo, 1996; Mucina and Rutherford, 2006).

This biome is found in the Eastern Cape and the Western Cape, in semi-arid areas, mainly across the Cape Fold Belt on a broad variety of soils (Mucina and Rutherford, 2006). In the Kouga Catchment it is represented in almost 18,000 hectares (less than 7 % of the catchment) (*Figure 17*). This biome is not represented in the Langkloof, but it extends over the catchment from west to east next to the Kouga River and around the north-east boundaries of the catchment, where the Kouga dam is located.

The Groot Thicket type covers almost 15,000 ha in the catchment (around 5 % of its total area) (*Table 7*). It can be found in the Kouga River and at the boundaries of the Baviaanskloof in the Kouga catchment, occupying ridges with moderate to steep slopes in an altitude range from 200-1100 m and with medium annual precipitation between 250-450 mm. Spekboom (*Portulacaria afra*) is characteristic of this vegetation type under favourable conditions, as well as succulent trees such as *Aloe ferox* and *Euphorbia tetragona* (Mucina and Rutherford, 2006).

Covering around 1 % of the Kouga catchment in a constrained area north-west of it (*Table 7*; *Figure 17*), the Gamtoos Thicket is distributed over an altitude range of 0-700 m on low ridges and steep areas of low mountains, which are protected against fires. With a low differentiation of strata, shrubs, trees and succulent are dominant (Mucina and Rutherford, 2006).

1.4 Fauna

As previously mentioned, the Langkloof valley and its surroundings are exposed to large variations in climatic conditions and are subjected to a number of so-called micro-climates. As a result, the different biomes in the area provide a habitat for a number of animal species. The Langkloof is linked to the Kouga catchment, and as such, many of the catchment's fauna also occurs in the Langkloof. While most of the larger, wild animals live in the mountainous areas, they can sometimes be seen on the mountain-slopes as well. The list of larger wild animals includes Cape Mountain Zebras, Cape Buffalos, Eland, Kudus, Red Hartebeest, Mountain Reedbuck, Klipspringer, Bushbuck, and many others (Veerkamp, 2013). In the vicinity of the Kouga catchment, there also exist game safaris and game hunting grounds.

A large variety of birds can also be observed in the Kouga catchment and the Langkloof. Swallows, sunbirds, kingfisher, African black eagles, amongst others are a common occurrence in the study area (Veerkamp, 2013). Reptiles, such as the leopard tortoise and smaller lizards appear in the area, and the fish in the rivers and lakes have a high level of endemism (Veerkamp, 2013).

Of particular interest for humans are large bee populations, which are essential for the deciduous fruit production, as they pollinate the flowers. On the other hand, moths and other insects can affect agricultural production negatively, which is why many farmers have to use pesticides in their orchards. Large and widespread families of baboons are also characteristic throughout the study area. They sometimes pick fruits from orchards and are attracted by organic waste, and are thus a concern for the farmers and inhabitants of the area (DFF 9).

1.5 Current State of Ecosystems

The current condition of South African ecosystems was evaluated in the National Biodiversity Assessment in terms of protection level and threat status (Driver *et al.*, 2011). Based on the results of that assessment and the boundaries of the study area, the current state of the ecosystems in the Kouga catchment is estimated and presented in *Table 8* and *Table 9*. In both cases, the respective categories of threat and protection levels represent the conservation status of each ecosystem according to its total distribution in the country. Therefore, this is a useful indicator to set conservation priorities, though it does not necessarily reflect the current condition of the catchment, which is described in the following section of this chapter.

Table 8. **National protection level of the ecosystems in the Kouga catchment**

Protection level	**Area (ha) in the Kouga catchment**	**% of Kouga catchment area**	**Criterion to determine protection level**
Well protected	101,478	36 %	More than 100 % of the biodiversity target is met in formal protected areas.
Moderately protected	131,782	47 %	Less than 100 % of the biodiversity target is met in formal protected areas.
Poorly protected	44,777	16 %	Less than 50 % of the biodiversity target is met.
Not protected	4,265	2 %	Less than 5 % of the biodiversity target is met.
Total	282,303	100 %	

Source: Driver *et al.* (2011)

According to the information presented in *Table 8*, more than 80 % of the ecosystems in the extended study area are moderately or well represented in formal protected areas in South Africa. Nevertheless, 16 % of the ecosystems in the catchment, which mainly belong to the Tsitsikamma Sandstone Fynbos vegetation type, are poorly protected in the country. The remaining 2 % of the catchment, classified as not protected, is entirely comprised of the Langkloof Shale Renosterveld vegetation.

Table 9. **Threat status of the ecosystems in the Kouga catchment**

Threat status[1]	**Area (ha) in the Kouga catchment**	**% of the Kouga catchment area**	**Criterion to determine protection level**
Endangered	101,478	2 %	Remaining natural habitat extent is larger than the biodiversity target, but it exceeds the target in less than a 15 %.
Vulnerable	131,782	14 %	Remaining natural habitat is less than 60 % of its original extent, but it is larger than the area to be considered endangered.
Least threatened	44,777	84 %	Remaining natural habitat is more than 60 % of its original extent.
Total	282,303	100 %	
[1] No critically endangered ecosystems are found in the Kouga catchment			

Source: Driver *et al.* (2011)

In terms of threat status, a broad majority of the ecosystems represented in the extended study area (more than 80 % of its surface) are classified as least threatened. However, the Tsitsikamma Sandstone Fynbos are vulnerable ecosystems at a national scale and they cover almost 40,000 hectares in the catchment (14 % of its total area). Categorised as endangered, the most threatened ecosystem in the catchment (in less than 2 % of its surface) correspond to Langkloof Shale Renosterveld (*Table 7-9*)

The sections below present land use and protected areas as an additional indication of the current status of the Kouga catchment in particular. Similarly, available information about invasive alien plant species is summarised in order to describe their role in the degradation of the ecosystems in the study area.

1.6 Land Use

Due to its fertile soils and suitable climate for agriculture, the landscape in the Langkloof valley has undergone intensive change. The different land use types that are present in the valley include natural vegetation, protected areas, cultivated land, degraded vegetation, urban built up, and waterbodies. Natural vegetation consists of areas untouched, or almost untouched, by human activities, with an abundance of native floral and faunal species. Such vegetation is mainly found on the mountain hills of the Tsitsikamma Mountains and the Kouga Mountains, or intermittently between settlements. A large portion of the land in the valley however has been changed into cultivated land to sustain agricultural productivity. As such, large parts of the landscape are characterised by widespread fruit orchards, and some grazing pastures for cattle and sheep. Degraded vegetation refers to a significant deterioration of natural vegetation, soil quality, or water resources, due to excessive human exploitation. It is thus a gradual destruction of natural vegetation and causes a reduction in the quality of the land. Urban built-up is considered as a removal of native vegetation and ecosystems in order to facilitate space for humans and their activities. This includes infrastructure such as industrial buildings, houses, and roads, which are typically clustered around the various settlements in the Langkloof valley. Waterbodies include both natural and human-made bodies of water, such as lakes, rivers and dams.

Figure 18 shows an overview of the Kouga catchment and its different land use types. This land cover representation has been updated by the South African National Biodiversity Institute (SANBI) in 2009 for the entire country.

Most of the catchment is covered by natural areas (about 90 %), which is similar for the Langkloof (roughly 60 %). However, the latter has a larger proportion of intensively cultivated land (almost 40 %), reflecting its importance as an agricultural area. The use of the land for agricultural purposes also explains why 0 % of the land in the valley is considered to be degraded, as agricultural cultivation has less negative effects on land quality than for example mining activities. It should be noted that only 2 % of the total surface area of the Langkloof is occupied by human settlements and structures. Similarly, only 1 % of the surface area consists of waterbodies. This figure clearly highlights the importance and prevalence of agriculture for the Langkloof compared to its other types of land use.

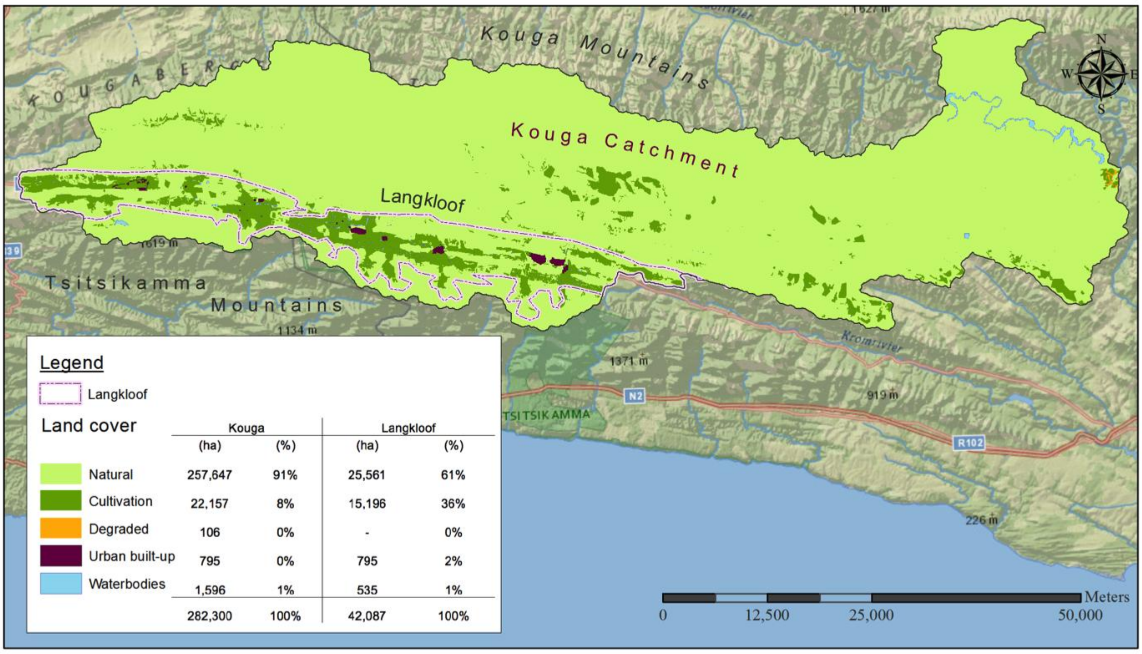

Figure 18. **Land cover in the study area (SANBI, 2009)**

1.6.1 Protected areas

This section examines the protected areas with formal status according to the Protected Areas Act, 2003 (No 57 of 2003). Protected areas have been established in order to preserve the rich biodiversity of the natural habitat. In the Langkloof, the mountain hills of the Kouga Mountains are protected as part of the Baviaanskloof Nature Reserve, and the Formosa Nature Reserve near Joubertina protects an area of roughly 2,640 hectares (Erlank *et al.*, 2009). Consistently, the formal protected areas in and around the Kouga catchment depicted in *Figure 19* are taken from the National Biodiversity Assessment (Driver *et al.*, 2011). As presented in the figure, the Baviaanskloof Nature Reserve is the main protected area in the Kouga catchment (protecting approximately 80,000 hectares in it). After this mega reserve, the Formosa Nature Reserve protects approximately 3,000 hectares and the Garden Route National Park extends over around 1,000 hectares in the Kouga catchment. In total, the Kouga catchment comprises almost 84,000 ha of formally protected areas, whereas the Langkloof only includes a minimum part (roughly 300 hectares) of the Formosa Nature Reserve (estimation based on Driver *et al.*, 2011).

The cartographic analysis of the protected areas updated by Driver *et al.* (2011) and the vegetation (Mucina and Rutherford, 2006) in the Kouga catchment allows determining the main protected vegetation types in the study area. Most of the formally established areas protect Fynbos vegetation (89 % of the protected area in the Kouga catchment), specifically the Kouga Sandstone Fynbos (65 % of the protected area in the catchment) and Kouga Grassy Sandstone Fynbos (17 % of the protected area) types. The remaining 11 % of the protected surface in the catchment mostly protects Groot Thicket vegetation (10 % of the area under protection in the catchment).

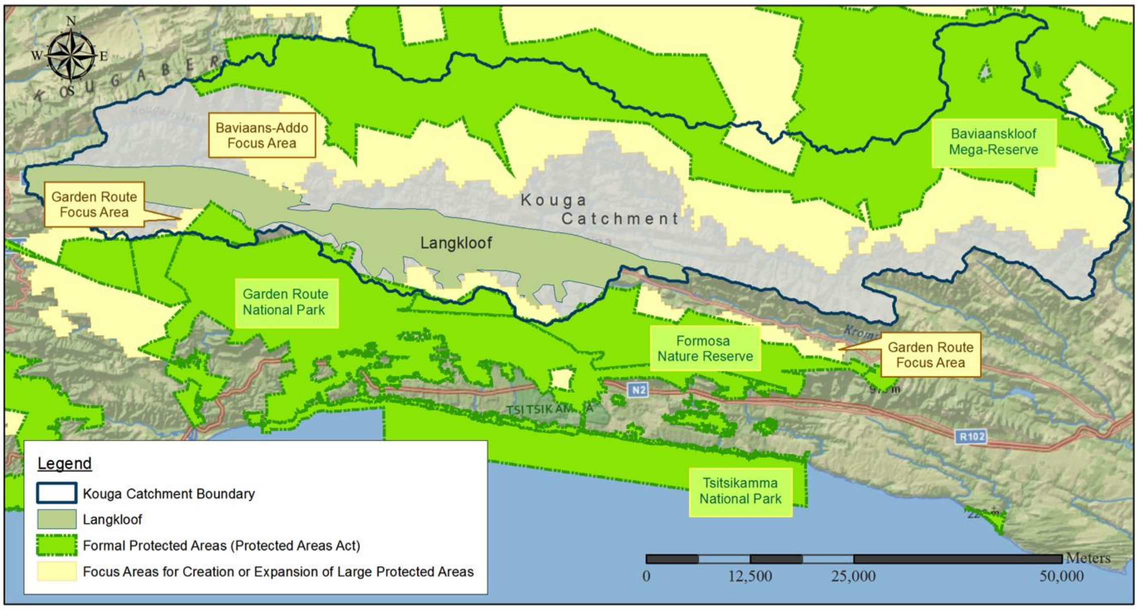

Figure 19. **Formal Protected Areas (Driver *et al.*, 2011) and Focus Areas for expansion or creation of new large protected areas (Government of South Africa, 2008)**

The Cape Floristic Region, which includes the Kouga catchment, is considered as one of the South Africa's nine priority conservation areas in the National Spatial Biodiversity Strategy (Rouget *et al.*, 2005). In order to narrow down this definition for fine-scale decision making purposes, the National Protected Areas Expansion Strategy (Government of South Africa, 2008) determined a list of 42 focus areas for the creation or expansion of large protected areas. In the study area, around 65,000 hectares of the Kouga Mountains are included in the Baviaans-Addo focus area, as well as approximately 4,000 hectares of the Tsitsikamma Mountains are considered in the Garden Route focus area for future expansion (*Figure 19*). As well as the currently protected areas, focus areas in the Kouga catchment are mostly aimed at protecting Fynbos vegetation types. In fact, about 90 % of the surface considered for further expansion or creation of new protected areas in the Kouga catchment extends over the same currently protected vegetation types, namely Grassy Sandstone Fynbos and Sandstone Fynbos. On the other hand, despite eing categorised as endangered in South Africa (Driver *et al.*, 2011), the Langkloof Shale Renosterveld is neither currently protected nor included in the focus areas for conservation in the Kouga catchment.

1.7 Invasive Alien Plant Species

Recognising its threat to ecosystem stability, many scientists have researched the impacts of IAPs throughout the world in recent decades (Vilà *et al.*, 2011; Powell *et al.*, 2011; Liao *et al.*, 2008). As such, it has become widely accepted that IAPs have a negative effect on local biodiversity, influence ecosystem stability such as provision of water and nutrients, and can have an impact on human well-being (Vilà *et al.*, 2011), as was already mentioned earlier.

Large parts of the Langkloof valley have recently become infested with IAPs, and this infestation is growing at an alarming rate (Richardson and van Wilgen, 2004). More precisely, the spreading of IAPs is a cause for concern not only in the valley, but also in the surrounding Kouga catchment and the entirety of South Africa. Most of these invasive species originally came from Europe or Australia, during a time when white people from those countries journeyed to South Africa and began to build settlements. They brought with them species that would grow fast and which would thus be well suited for the building of houses and structures. Other earlier uses of IAPs included the use as firewood, the provision of shade, for windbreaks, amongst other uses (Poynton, 1979; Moyo and Fatunbi, 2010). Since the middle of the seventeenth century, around 750 tree species and approximately 8,000 shrubby, succulent and herbaceous species have been introduced to South Africa (van Wilgen *et al.*, 2001). Out of these, a total of 161 species are regarded as invasive and are therefore a cause for concern for the rich bio-diversity. Many of these introduced species were used for commercial purposes, such as the softwood species *Pinus* spp., of which there exist approximately 700,000 hectares of plantations in South Africa, and the hardwood species wattles, eucalypts and poplar, which occupy roughly 625,000 hectares (Nyoka, 2003). Van Wilgen *et al.* (2001) record that an area exceeding 100,000 km² of natural vegetation in South Africa is currently invaded by IAPs, which is more than 8 % of the country's total surface area, whereas the Department of Water Affairs reports a number as high as 10 % (DWAF, 2012). Many of these IAPs reproduce fast, grow rapidly and out-compete native species due to a lack of natural predators (Richardson *et al.*, 2000; van Wilgen *et al.*, 2001). As a result, bio-diversity in infested areas is decreasing, and 750 native plant species are threatened with extinction due to IAPs (de Wit *et al.*, 2001). Due to its widespread occurrence and its fast spreading rate, the most concerning IAPs in the study area is *Acacia mearnsii* (black wattle) (*Table 10*).

 

Table 10. **Overview of *A. mearnsii***

Genus/ Species	Origin	Characteristics	Ecological Impacts (Langkloof)
Acacia / *A. mearnsii*	Australia	- fast spreading (large amounts of long-lived seeds with prolific and precocious seed dispersal) - fast growing - bound to waterways - increases height and biomass of vegetation	- replaces native vegetation - increases rainfall interception - increases transpiration - reduces soil moisture - destabilizes stream banks - reduces carrying capacity and profitability of agricultural land - disrupts ecosystem stability

Source: Global Invasive Species Database (Invasive Species Specialists Group (ISSG) of the IUCN Species Survival Commission).

While *A. mearnsii* is by far the most common and most worrying IAP in the Langkloof area (McConnachie, 2012), the spreading of another IAP most notably in the western part of the valley, needs to be mentioned as well. *Hakea* is a genus consisting of many shrub and small tree species, and is spreading at an alarmingly fast rate in the western Langkloof near the settlements of Misgund and Haarlem (Fugler, 1982). It has originally been introduced to South Africa for its ornamental uses. Most prominent amongst the *Hakea* species in the western Langkloof is *H. sericea* (Gordon and Fourie, 2011), of which *Table 11* provides a brief overview.

There exist also other IAPs in the Langkloof area, such as species of *Eucalypts*, *Pinus* and *Opuntia* (Veerkamp, 2013), whose ecological impact and distribution however is considerably less impactful than those of *A.mearnsii* and *H. sericea*.

Table 11. **Overview of *H. sericea***

Genus/ Species	Origin	Characteristics	Ecological Impacts (Langkloof)
Hakea / *H. sericea*	Australia	- highly branched, prickly shrub - resistant to drought, wind and cold - most commonly found on mountain hills - large and prolific seed bank	- replaces native vegetation - increases fire hazards - reduces soil moisture and water yields - reduce surface runoff - disrupts ecosystem stability

Source: Invasive Species Compendium (Commonwealth Agricultural Bureaux International (CABI)).

Invasive alien plant species have a considerable negative effect on the environment, as they have been shown to reduce surface stream flow, reduce the availability of water due to increased water uptake, increase soil erosion, contribute to a more rapid spreading of fires, affect soil nutrient status, affect habitat suitability for native species, and reduce bio-diversity. More precisely, studies have shown that IAPs reduce stream flows between 4.7 and 13 percent (Dye and Poulter 1995; Le Maitre *et al.*, 1996; Prinsloo and Scott, 1999; Le Maitre *et al.*, 2000), and use 10 % of the utilizable surface runoff annually (Le Maitre *et al.*, 2000). In a water-stressed country such as South Africa, this can potentially have devastating consequences in the future. But apart from their ecological effect, they also directly negatively impact the nation's economy. IAPs also reduce the amount of potentially arable land, reduce grazing potential, poison humans and livestock, increase the amount of imported water, and cause considerable costs in terms of fire control and clearing efforts. It is therefore not surprising that the spreading and analysis of IAPs has been a hot topic for research in the past decades (Le Maitre *et al.*, 1996; Prinsloo and Scott, 1999; Holmes and Marais, 2000; Le Maitre *et al.*, 2000; van Wilgen *et al.*, 2001).

Fynbos, the pre-dominant vegetation type in the Langkloof and its surrounding, is the most heavily infested vegetation type. As such, the spreading of IAPs is one of the most pressing challenges in the area. For this reason, South Africa's government has created the Working for Water (WfW) program as a means to combat the spreading of IAPs in 1995 (McConnachie *et al.*, 2012). The Kouga catchment area was chosen as the first area on which the WfW program would focus on, due to its great ecologic importance and its heavy infestation. The program has a spear-headed objective, as it aims to create work opportunities for the many unemployed people, while simultaneously controlling and eradicating IAPs. It has been called the world's most ambitious invasive alien plant control programme by Kader Asmal, a founding minister of the programme, but its success is disputed.

2 Appendix II – Stakeholder Meetings

2.1 Water Learning Journey

This workshop, organized by the non-profit organization Living Lands, took place on the 16th and 17th of October, 2014. Its goal was to bring together various stakeholders involved in the provision and security of water in the Langkloof. It included representatives of government departments: three actors from the Department of Water Affairs and Sanitation, and one employee of the Department of Rural Development and Agrarian Reform. Also, the head of the Joubertina unit of the Koukamma municipality was present, as well as representatives of a local NGO (LOWFT), a consultant to the Haarlem irrigation board, and various deciduous fruit farmer.

From a meeting place in Joubertina, the water learning journey took these stakeholders to various locations in the Langkloof, such as dams and water treatment facilities, in order to share experiences and learn about the management of water in the Kouga catchment and the Langkloof. The participation in this water learning journey provided valuable first insights into the complexity of the water issue, and the main problems centred on water management.

2.2 SmartAgri Workshop in Oudtshoorn

The Smart Agriculture for Climate Resilience (SmartAgri) project is a project hatched by the Western Cape Department of Agriculture, the Western Cape Department of Environmental Affairs & Development Planning and the University of Cape Town's African Climate and Development Initiative. The goal of the project is to identify risks and opportunities of future climate change for the agriculture sector in the Western Cape. Hence, the different actors involved have worked on a Status Quo Review of the impacts of climate change on agriculture in the Western Cape.

Living Lands have joined the project as a facilitator and was instrumental behind the organization of a first workshop in Oudtshoorn on the 16th of October 2014. The workshop brought together a variety of stakeholders involved in the agricultural sector, such as government officials, fruit farmer and representatives of fruit farmer associations. By conducting group discussions and performing tasks in groups, the workshop participants helped to identify various issues that could inhibit a growth of the agricultural sector in the face of climatic change. Furthermore, the workshop was used to establish an agreement to participate and contribute to the project in future workshop and stages. The meeting was especially helpful to collect information on the impacts and proportions of future climate change.

2.3 Formosa Meeting of Stakeholders

This meeting took place in Joubertina on the 21st of October, 2014. Similar meetings take place a number of times during the year, although the spacing between meetings is irregular, and can sometimes be as much as three or more months. The aim of the meeting was to address concerns and issues of various stakeholders concerning the state of the Formosa Nature Reserve. The meetings generally involve representatives of the municipality, the farmers, different experts, and various other stakeholders, such as employees of the Eastern Cape Parks and Tourism Agency, the Eden to Addo initiative and Living Lands. Participating in this meeting was helpful to obtain information about disaster and risk management in the Langkloof and to learn more about the main issues in protected areas.

3 Appendix III – Overview of interviewees

Below is an overview of the Langkloof stakeholders that were interviewed during this research. *Table 12* provides an overview of the interviewed deciduous fruit farmer, whereas *Table 13* represents the interviewed experts and governmental actors. Their names have been denoted as DFF 1, DFF 2, ... so as to preserve their anonimity.

***Table 12*. Overview of interviewed deciduous fruit farmer in the Langkloof.**

Farmer	Area (ha) under fruit	Settlement	Pome fruit		Stone fruit				Other businesses in the farm				
			Apple	Pear	Apricot	Peach	Nectarine	Plum	Livestock	Honeybush	Nursery	Packhouse	Others[1]
DFF 1	250	Joubertina	□	□	□	□		□	○				
DFF 2	560	Louterwater	□	□								○	
DFF 3	200	Avontuur	□	□		□			○				
DFF 4	214	Misgund	□	□						○			
DFF 5	72	Ongelegen	□	□			□	□	○				
DFF 6	945	Haarlem, Misgund, Louterwater, Joubertina and Twee Riviere	□	□				□	○			○	○
DFF 7	170	Louterwater	□	□				□					

Farmer	Area (ha) under fruit	Settlement	Pome fruit		Stone fruit				Other businesses in the farm				
			Apple	Pear	Apricot	Peach	Nectarine	Plum	Livestock	Honeybush	Nursery	Packhouse	Others[1]
DFF 8	110	Haarlem	▯	▯		▯		▯	O				O
DFF 9	23	Louterwater	▯	▯									
DFF 10	270	Avontuur, Haarlem, Misgund, Joubertina and Twee Riviere	▯	▯									O
DFF 11	80	Louterwater	▯	▯	▯	▯	▯	▯					
DFF 12	250	Twee Riviere	▯	▯							O		
DFF 13	250	Louterwater	▯	▯									

[1] The others category includes packhouses, guesthouses and a bottling plant.
!! = main fruit that is produced and O other business activities in the farm(s)

Source: Interviews conducted in 2014 in the Langkloof

***Table 13*. Overview of interviewed experts and governmental actors in the Langkloof.**

Expert or governmental actor	Settlement	Expertise or role in the organization	Close ties to…		
			Government	Fruit Farmer	Other actors / industries
EXP 1	Haarlem	Consultant for the Irrigation Board of Haarlem		X	X
EXP 2	Joubertina	Consultant and Senior Civil Engineer	X		X
EXP 3	Twee Riviere	Head of local NGO and specialized in social development	X	X	X
EXP 4	Joubertina	Retired technical advisor for the Department of Agriculture and Forestry for 40 years – now activist in the area	X	X	X
EXP 5	Joubertina	Project Manager for Gamtoos Irrigation Board of WfW	X	X	X
EXP 6	Joubertina	Chairperson of the Residence Association			X
EXP 7	Louterwater	Beekeeper		X	X
EXP 8	Joubertina	Beekeeper		X	X
GOV 1	Kareedouw	Management of Water and Sanitation for the Koukamma Municipality	X		X
GOV 2	Joubertina	Head of the Joubertina Unit of the Koukamma Municipality	X	X	X
GOV 3	Kareedouw	Station commander of the fire department of the Koukamma		X	

		Municipality			
GOV 4	Jeffrey's Bay	Environmental Officer for Biodiversity - Department of Environmental Affairs	X		
GOV 5	Jeffrey's Bay	Environmental Officer - Department of Environmental Affairs	X		X
GOV 6	Kareedouw	Senior Disaster Management Officer of the Sarah Baartman District Municipality	X		
GOV 7	Port Elizabeth	Co-ordinator of agricultural and rural development - Department of Rural Development and Agrarian Reform	X		X
GOV 8	Joubertina	Office manager - Department of Rural Development and Agrarian Reform	X	X	

4 Appendix IV – Interview guidelines for Deciduous Fruit Farmer

Below (*Table 14*) is an example of an interview with a deciduous fruit farmer in the Langkloof. While interview questions were slightly adjusted throughout the field research, this is a good reflection of the overall topics and themes that were covered in almost all interviews that included fruit farmers. Furthermore, in many interviews follow-up questions presented themselves on a number of topics, depending on e.g. if an interviewee had multiple farms, or if an interviewee was involved in a BEE scheme.

***Table 14*. Example of an interview with a deciduous fruit farmer.**

Date of interview:		Time of interview:	
Organization or Stakeholder:			
Interviewee name:		Role/function in organization:	
Interviewers:			
Primary note-taker:		Translator:	

	Question	Answer	Keywords/Themes
1.	What is the size of your farm(s)?		Background
2.	How many hectares do you have for the production of fruits?		Background
3.	What fruit(s) do you farm?		Background
4.	Other farming practices? (vegetables, livestock, honeybush, bees)		Background

5.	How many employees do you have? How many permanent / seasonal?		Background
6.	Where is your main market located?		Business
7.	Do you also export internationally?		Business
8.	Do you need to meet any international standards? (Which one, how do they impact, etc… Global GAP, …)		Business
9.	What are you spending the majority of your business' budget on?		Business
10.	What kind of changes would you like to make in your business in the future?		Business
11.	Do you use any local products for farming?		Inputs
12.	What kind of fertilizers do you use? Do you use any natural / organic fertilizers?		Inputs Fertilizers
13.	What percentage of your budget goes to the purchase of fertilizers?		Inputs Costs
14.	Do you use pesticides? Which types?		Inputs Pest control
15.	What percentage of your budget goes to the purchase of chemicals?		Inputs Costs
16.	Do you use any kind of technology to improve your crops?		Crop improvement
17.	Do you use any environmentally friendly farming practices? What kind? (e.g. mulching, less chemicals, green labels, water saving practices, IAP clearing, etc.)		Environmentally friendly practices
18.	What compelled you to use them? What would need to happen for you to use them?		Environmentally friendly practices
19.	In your opinion, what is it that you get from nature and that benefits you? (i.e. what are the benefits of nature for you?)		Ecosystem Dependence Ecosystem Services
20.	What are the main issues that you and your business are dealing with on a regular basis? (e.g. water shortages, IAPs, climate change …)		Concerns and issues
21.	How do you deal with these issues?		Concerns and Issues
22.	Have you observed any changes in these issues? How do you expect these issues to develop in the future?		Future
23.	What are the biggest financial risks of your business?		Business Risks

24.	How do you deal with it?		Business Risks
25.	Have you ever been affected by floods, droughts, fires, water shortage and hailstorms? To what extent was your production affected?		Risks Extreme events
26.	How did you cover those costs? How do you deal with these events?		Insurance Strategy
27.	Are you insured against extreme events?		Insurance
28.	If yes, do you perceive any gaps in your insurance cover in this regard?		Insurance
29.	Do you perceive any dependence of your business on natural pollinators? (How?)		Ecosystem dependence Trends in ES Pollination
30.	Do you perceive any dependence of your business on any kind of natural pest control (e.g. bats, snakes, …)?		Natural Pest control
31.	Is soil erosion a problem for you? Do you know of any soil erosion prevention measures? Have you ever invested in these measures, and, if yes, how much?		Soil Erosion
32.	What do you think about tourism in the Langkloof? Do you think you could benefit from them?		Tourism
33.	How do you deal with IAPs? Part of WfW? Do you clear your land?		Invasive alien plant species (IAPs)
34.	If part of WfW, what do you think about it?		Working for Water
35.	What is your opinion on biological control methods for IAPs (e.g. seed-feeding weevil, release of fungal pathogen, …)		Biological control methods
36.	Do you depend on any kind of technology to obtain and purify water?		Ecosystem dependence Water purification
37.	In what way do you think Climate Change could impact your business in the future? (e.g. production losses? Damages from adaptation? Water shortages? more IAPs, human health issues?)		Climate change
38.	What do you think are measures to deal		Climate change

	with these concerns?		
39.	How dependent is your production on weather and weather variability?		Climate change
40.	Have you observed any changes in the weather in the past years and/or decades?		Climate change
41.	Are you a member of a local farming organization (e.g. FA, Irrigation Board, BEE…)		Partnerships and collaboration
42.	How often do you meet and what topics are discussed?		Partnerships and collaboration
43.	How are these results (if they are) communicated to the authorities?(municipalities/government)		Partnerships and collaboration
44.	How would you describe the communication with other stakeholders in the area?		Communication
45.	Do you think the issues around communication are going to improve?		Communication
46.	Are you involved in any other kind of partnership? (e.g. WfW, municipalities, other government actors, NGOs, Universities)		Partnerships and collaboration
47.	With whom do you think a partnership could be beneficial and successful in the future, and why? (government, other farmers, NGOs, universities, other industries, …)		Partnerships and collaboration
48.	Feedback? Is there anything that we have not covered and you would like to mention?		Feedback

5 Appendix V – Rough Interview Guidelines for Experts / Government Actors

Below (*Table 15*) is an example of an interview with an expert or a governmental actor. As each individual person had different specialisations and different knowledge, it was important to adjust each interview beforehand, to tailor it to the interviewee. Especially for experts, a specific topic was often of key importance during the interview, if the interviewee was, for example, especially knowledgeable about IAPs, or about the interactions between stakeholders in the Langkloof. Thus, the different experts and government interviews differed more from each other than the interviews conducted with fruit farmers. An interview with a beekeeper was structured entirely different than an interview with an office manager of the Department of Agriculture. Nonetheless, the example presented below provides an overview of the general themes that were covered and the approach that was taken for a stakeholder interview.

***Table 15*. Example of an interview with an expert or a government actor in the Langkloof. Depending on the interviewee and his expertise, questions were adjusted beforehand to better extract the knowledge of the interviewee.**

Date of interview:		Time of interview:	
Organization or Stakeholder:			
Interviewee name:		Role/function in organization:	
Interviewers:			
Primary note-taker:		Translator:	

	Question	Answer	Keywords
1.	What is your role in the organization?		Background Personal Information
2.	Can you tell us about your responsibilities?		Background Personal Information
3.	Can you tell us about your experience and expertise?		Background Personal Information
4.	To what extent are you/is your department working and/or present in the Langkloof area?		Langkloof
5.	What do you think is the primary importance of the Langkloof area?		Langkloof.
6.	What is your main long-term goal in the Langkloof?		Langkloof
7.	What actions do you take to achieve that goal?		Actions in Langkloof
8.	If an organization, how many employees / representatives are present in the Langkloof?		Langkloof
9.	In what way have you or your department contributed to advancements in the Langkloof?		Actions in Langkloof
11.	Do you have any data on your activities in the Langkloof (or Eastern Cape), or any reports that		Actions in Langkloof

	document projects?		
12.	What has been going well, and what could have gone better in regards to activities in the Langkloof?		Actions in Langkloof
13.	What is your experience with DFF in the Langkloof?		Stakeholder Interaction
14.	To what extent have you supported/worked with fruit farmers in the Langkloof?		Stakeholder Interaction
15.	What do you think is the relationship between the fruit farming industry and the citizens/government/municipality in the settlements?		Stakeholder Interaction
16.	What are the main issues that you or your organization is dealing with in the Langkloof area?		Concerns and Issues
17.	How are you dealing with these issues?		Concerns and Issues
18.	What are the main social issues that you are experiencing in the Langkloof, and how do you think these issues should be solved?		Concerns and Issues
19.	Are there any issues that are specific to only the Langkloof that you are not experiencing elsewhere?		Concerns and Issues
20.	Are there any issues or conflicts of interest with the local municipalities or the fruit farmers?		Concerns and Issues
21.	If so, what issues and how can they be dealt with?		Concerns and Issues
22.	If you were to look 5 or 10 years into the future, how do you think the issues and the situation in the Langkloof area will develop?		Future
23.	Is the situation in the Langkloof getting better or worse, in your opinion, and why?		Future
24.	What do you think will be major obstacles in the future, and why?		Future

25.	What do you think needs to happen to solve the issues in the Langkloof area around water security, job security, agricultural production, environmental sustainability...?		Future
26.	Are you taking any actions to ensure that this happens and which?		Actions
27.	What is your opinion on climate change for the Langkloof?		
28.	What role does Climate Change play for you at present? Are you taking any actions to accommodate for Climate Change or to reduce the impact it might have in the future?		Climate Change
29.	Which governmental departments are you working closely with about issues concerning the Langkloof (or Eastern Cape) area?		Communication
30.	Which actors in the Langkloof are you regularly working/meeting with?		Communication
31.	How often do you communicate with those other stakeholders?		Communication
32.	How would you describe the communication between you or your organization and the other stakeholders? Do you communicate well or could things be better, and in what way?		Communication