Exploring ethical challenges, climate change and implications on land and water use within the agricultural sector of the Garden Route, Western Cape, South Africa

by
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DECLARATION

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ABSTRACT

Climate change creates both risks and opportunities worldwide. By understanding, planning for and adapting to a changing climate, individuals and societies can take advantage of these opportunities and reduce risks where possible. The consequences of climate variability and climate change are potentially more significant for activities that depend on local weather and climatic conditions. The Garden Route in the Western Cape (southern region), is an agricultural region that is vulnerable to the impacts of climate change and climate variables; if these climatic conditions should change, productivity levels and livelihoods would be directly affected. This study examined how farmers' perceptions of weather conditions have corresponded with the climatic data recorded at various meteorological stations in the Garden Route, South Africa, and whether these perceptions could be linked to an understanding of the ethical implications of climate change or not. Through the use of indepth interviews, the study analysed farmers' adaptive responses, their perceptions and understanding of climate change, and their perceptions and understanding of the ethical challenges posed by climate change.

The Heckman Probit Adaptation Model was used to examine perception and adaptation to climate change and climate variability. Main constraints cited by farmers in changing their ways of farming and adapting to climate change were obtaining rights to increasing their water storage capacities (increasing dam walls or building dams), flood water management, cash flow and financial support, obtaining permits to burn, and general support from official structures. Furthermore this study implemented a scenario-planning exercise to determine adaptation trends in the observed and projected climate for the Garden Route, with the aim of providing possible solutions for wiser agricultural practices. The following scenarios were compared: (1) If agricultural practices continue as per status quo – with no change in climatic conditions; (2) If agricultural patterns are significantly modified, to reduce agricultural impact on local biodiversity – with no change in climatic conditions; (3) If agricultural practices continue as per status quo – with significant change in climatic conditions; and (4) If agricultural practices are significantly modified, to reduce agricultural impact on local biodiversity, and taking account of likely changes in climatic conditions. The analyses – according to these four scenarios – indicated the likelihood of possible trends in future, using specific climate variables, together with possible adaptation strategies. With no change in climatic conditions, but a change in

farming practices towards environmental protection, the farming sector may achieve sustainability. However, if climatic conditions should change, changes in farming practices may not be enough to guarantee its sustainability. Farmers in the Garden Route indicated that agricultural production on any scale is completely dependent on water, leaving this sector exposed and vulnerable posing substantial obstacles to farmers to continue farming in the same way. Farmers are now faced with the decision to "adapt or die". The convergence of these factors has the potential to create a "perfect moral storm". One consequence of this storm is that, even if the other difficult ethical questions surrounding climate change could be answered, farmers still may find it difficult to articulate what this moral storm could entail, and how to act upon it.

OPSOMMING

Klimaatsverandering skep wêreldwyd beide risiko's en geleenthede. Deur klimaatsverandering te verstaan, daarvoor te beplan en daarby aan te pas, kan individue en gemeenskappe hierdie geleenthede aangryp en, waar moontlik, die risiko's verlaag. Die gevolge van klimaatskommelings en klimaatverandering is potensieel meer betekenisvol vir daardie aktiwiteite wat afhanklik is van plaaslike weer- en klimaatstoestande. Die landboustreek in die Tuinroete in die Wes-Kaap (suidelike streek) is gevoelig vir die impak van klimaatsverandering en klimaatskommelings; indien klimaatstoestande verander, sal produktiwiteitsvlakke en lewenskwaliteit direk beïnvloed word. Hierdie studie het ondersoek ingestel na die ooreenkoms tussen boere se persepsie van klimaatsverandering, en die klimaatsdata by verskeie meteorologiese stasies in die Tuinroete, Suid-Afrika en of hierdie persepsies verbind kan word aan 'n begrip van die etiese implikasies van klimaatsverandering of nie. By wyse van indiepte onderhoude het die studie boere se aanpassingmeganismes, hul persepsies en begrip van klimaatsverandering, asook hul persepsies en begrip van die etiese uitdagings van klimaatsverandering ontleed.

Die Heckman Probit Aanpassings-Model is gebruik om die persepsie en aanpassing by klimaatsverandering en klimaatskommelings te bepaal. Boere het die volgende as die vernaamste struikelblokke in die verandering in landboupraktyke en aanpassing by klimaatsverandering beskou: a) verkryging van toestemming om wateropgaarkapasiteit te verhoog (die bou of verhoging van damme); b) vloedbestuur; c) kontantvloei en finansiële ondersteuning; d) verkryging van brandpermitte; en e) algemene ondersteuning vanaf amptelike instansies. Voorts het hierdie studie scenario-beplanning gebruik om tendense in die aanpassing by die waargenome en voorspelde klimaatsverandering in die Tuinroete te bepaal. Die doel hiervan is om moontlike oplossings vir beter landboupraktyke te verskaf. Die volgende scenario's is met mekaar vergelyk: (1) Indien landboupraktyke voortgaan soos gewoonlik (status quo) – geen verandering in klimaatstoestande; (2) Indien landbou betekenisvol verander om die impak van landbou op plaaslike biodiversiteit te verlaag – geen verandering in klimaatstoestande; (3) Indien landboupraktyke voortgaan soos gewoonlik (status quo) – betekenisvolle verandering in klimaatstoestande; en (4) Indien landbou betekenisvol verander om die impak van landbou op plaaslike biodiversiteit te verlaag – met inagneming van moontlike

veranderings in klimaatstoestande. By wyse van die vier scenario's dui die analise moontlike toekomstige tendense aan deur gebruik te maak van spesifieke klimaatskommelings, tesame met moontlike aanpassingstrategieë. Met geen verandering in die klimaatstoestand kan die landbousektor volhoubaar wees indien landboupraktyke verander en omgewingsbeskerming in ag neem. Indien klimaatstoestande egter verander, mag gewysigde landboupraktyke nie genoeg wees om die volhoubaarheid daarvan te verseker nie. Boere in die Tuinroete het aangedui dat enige skaal van landbouproduksie geheel en al van water afhanklik is, wat hierdie sektor blootgestel en kwesbaar maak, en 'n groot struikelblok is indien boere op dieselfde wyse bly boer. Boere is nou onderworpe aan die besluit om aan te pas of onder te gaan. Die sameloop van al hierdie faktore het die potensiaal om die "perfekte morele storm" te ontketen. Een gevolg van hierdie storm is dat, alhoewel ander moeilike etiese kwessies rondom klimaatsverandering beantwoord sou kon word, boere dit nog steeds moeilik mag vind om dié morele storm te omskryf en hoe om hierop te reageer.

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LIST OF ABBREVIATIONS

CGIAR	Consultative Group on International Agricultural Research
DEA	National Department of Environmental Affairs
FAO	Food and Agriculture Organization of the United Nations
GCMs	Global Climate Change Models
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
MAP	Mean annual rainfall (precipitation)
MNL	Multinomial Logit
PES	Payments for Ecosystem Service
SARVA	South African Risk and Vulnerability Atlas
WESSA	Wildlife Society of South Africa
WMA	Water Management Area
WMA	Water Management Association

CHAPTER 1: **INTRODUCTION**

1.1 Preamble

A significant portion of the agricultural sector within the Garden Route region[1], South Africa, currently faces two major issues: financial instability and environmentally unsustainable farming practices (Hannes Muller, Land Care, pers comm, 20 September 2010). The overarching aim of this study was to identify and promote logical and financially feasible adaptation alternatives that will encourage wise and sustainable use of land and water resources within the agricultural sector of the Garden Route. The study focused on the perceptions of commercial farmers operating on the wave-cut platform and within the floodplains of the coastal rivers and estuaries of the Garden Route regarding weather and climate, adaptation strategies to adapt to climate change, and their perceptions and understanding of the ethical challenges brought about by climate change and adapting to it. These findings were utilised to make recommendations relating to ethically justifiable mitigation and adaptation strategies to the Garden Route agricultural community.

1.2 Introduction and objective of the study

The misuse of land and water resources has resulted in significant environmental degradation throughout the Western Cape. Our water resources are particularly vulnerable; more than 90% of the river systems in the Western Cape, are endangered or critically endangered (Driver *et al*, 2004).

Figure 1.1: Gwaing river flowing into the ocean, near George

[1] The Garden Route region covers the George, Knysna and Bitou and Mossel Bay municipal areas, and beyond their northern boundaries up to the N9 and R62 roads in the Western Cape (Garden Route Critical Biodiverity Areas Map, SANBI, 2010).

The Garden Route area falls within the Gouritz Water Management Area (WMA). 275 million m^3 of water is made available, each year, in this WMA. The human requirements for this area (comprising agriculture, urban, industrial, recreational – such as golf courses, etc.), are 339 million m^3 per year. This means that there is already a deficit of 64 million m^3 of water per year (DWAF, 2004). If the current, unsustainable land and irrigation practices, coupled with further erratic rainfall patterns continue, it may result in wide-scale food and water shortages.

It is possible that farmers will look to utilise more land (currently occupied by conservation-worthy indigenous vegetation), and tap more water resources in the near future as current trends of climate change in the area (that will be discussed below) continue. This will cause further destruction to the Cape Floral Kingdom's fragile biodiversity, as well as undermine the most important asset of the Western Cape: our natural resources. Farming practices therefore need to be adjusted so that effective changes can be implemented to avoid such wide-scale damage. This also creates ethical challenges for farmers in the Garden Route. Many people subscribe to a "utilitarian ethics" meaning that when evaluating an action, the outcome of that action is judged with reference to its effect on fellow humans. They ask the question: Does the action produce the greatest good for the largest number of people? If the answer is "yes", then the action is deemed good. However, this does not mean that the ends justify the means, or that choosing the lesser of two evils is always good, because actions in themselves also have an inherent ethical dimension (Chrispeels and Mandoli 2003). When applied to the agricultural sector in the Garden Route area, similar questions can be asked, for example: "Are the benefits of agriculture or adaptation to climate change, shared by many people or are they limited to benefit a narrow segment of society?" "What are the impacts of agriculture on both environment and humans, and what response from the farmers in the Garden Route to the challenge of climate change would, in terms of their net consequences, have ethically good concequences in the practise of agriculture?"

Another perspective according to Brad Hooker (2002) stipulates that a central moral idea is that doing a specific act is morally permissible only if others doing that act would also be morally permissible. One can argue that there are a number of different ways of developing this idea. Immanuel Kant, who is regarded as the philosopher who has founded the deontological approach to ethical theory, suggested that a "Categorical Imperative" operates as the foundational principle of morality. He formulated his Categorical Imperative in different ways (Hooker, 2002). One of his two main formulations of the Categorical Imperative develops the universalizability principle, or the "What if everyone did that?" question. The other main formulation of the Categorical Imperative develops the idea that morality does not permit you to use people merely for your own purposes, but rather as ends in themselves.

Furthermore, it is important to note that Kant's ethics is grounded in the distinction between hypothetical imperatives and categorical ones. In having universal rules (guided by either hypothectical or categorical imperatives), Kant himself admits that the application of these rules require phronesis, or differently stated, judgements sharped by experience (Treanor, 2009). By "hypothetical imperatives", Kant means imperatives that tell a person what to do in order to get or do something the person desires to do, for example, "If you want to be trusted, always keep your word and tell the truth". The Categorical imperatives, on the other hand, indicates to a person what to do regardless of any personal desires, for example, "Tell the truth even if you don't want to". As I will show further on in this study, this distinction is important because many of the farmers in the Garden Route have been confronted with ethical dilemmas since they made choices based on desires and preferences, an not ethical principles. For example: During the dry period that was recently experienced in the Garden Route from 2008 - 2010, farmers found themselves to be operating in a "survival mode", and in some instances, expanded their dam walls illegally (Hannes Muller, Land Care, pers comm, 20 September 2010). This in itself reflects the biophysical and ethical challenges that farmers struggle with on a daily basis.

However, the ethical challenges experienced by farmers in the Garden Route area with regards to climate change and adapting to it, are of a much more profound nature than merely a choice of principles to guide one's actions. Gardiner (2006 and 2011) describes these challenges as constituting a perfect moral storm – in that it challenges the very possibility of responding to climate change in an ethically responsible way (Hattingh, 2011). As Hattingh (2011: 96) has summarized this perfect moral storm: "Climate change confronts us with a systematic problem, the complexity of which makes it very difficult to tackle its challenges with conventional ethics and approaches to decision making".

Accordingly, the goal of this study was firstly to look at the perceptions that farmers in the Garden Route have on climate change. The study examined how farmers' perceptions of weather conditions have corresponded with the climatic data recorded at various meteorological stations in the Garden Route. Through the use of interviews, the study also analysed farmers' adaptive responses, as well as their perceptions and understanding of the ethical challenges emerging from this adaptation. On a factual level, the central question that guided this study could be formulated as follows: Are farmers' perceptions and adaptation measures in line with climate data records, as well as with the predicted southern Cape climate changes? On a normative level, the central question that guided this study was whether the farmers understood, and could appropriately respond to the ethical challenges posed by climate change in the Garden Route area and adapting to it?

Figure 1.2: The Outeniqua Nature Reserve in the Garden route

In order to answer the above the Heckman Probit Adaptation Model was used to examine perception and adaptation to climate change and climate variability. Furthermore this study implemented a scenario-planning exercise to determine adaptation trends in the observed and projected climate for the Garden Route, with the aim of providing possible solutions for wiser agricultural practices. A critical interpretation of the results of these two research tools provided valuable insights with regards to the understanding farmers have of the ethical challenges brought about by climate change and efforts to adapt to it.

1.3 The relevance of the study from a climate change perspective

Most of the Global Climate Change Models (GCMs) predict that the Western Cape will become drier and warmer in future (DEA&DP, 2008).

The National Department of Environmental Affairs is currently finalising a National Climate Change Adaptation Framework (DEA&DP, 2008). This framework consists of six themes:

1. Theme 1: Greenhouse gas emission reductions and limits
2. Theme 2: Build on, strengthen and/or scale up current initiatives
3. Theme 3: Implementing the “Business Unusual” Call for Action
4. Theme 4: Preparing for the future
5. Theme 5: Vulnerability and Adaptation
6. Theme 6: Alignment, Co-ordination and Co-operation

In terms of the framework given above, this study roughly falls within the component of “adaptation of agriculture to manage and/or minimise the impacts of climate change” but also goes beyond this categorization in so far as ethical dimensions of climate change are also discussed here.

The Food and Agriculture Organization of the United Nations (FAO,2009), states that the croplands, pastures and forests that occupy 60% of the Earth's surface, are progressively being exposed to threats of climate variability and, in the long run, to climate change. Changes in air temperature and rainfall, and resulting increases in frequency and intensity of floods, droughts and storms, have significant effects on the distribution of agro-ecological zones, habitats, pests and diseases, ocean circulation patterns and fisheries resources; all of which impact upon agriculture and food production.

Climate change, caused by human activities, has now been identified by a number of influential international studies, including those of the Intergovernmental Panel on Climate Change (IPCC 2012), to be a significant threat to human livelihoods and sustainable development in many parts of the world.

With the steady increase in people's awareness regarding climate change and the impact on the agricultural sector across the globe, the relationship between climate change, perception and adaptation has attracted considerable attention in recent years. In an attempt to go beyond assumptions, researchers from a variety of disciplines, focused on anything from environmental, economic, and social impacts; to aspects of ethical analysis and paradigm shifts to obtain solutions for the changing climate and future scenarios in developed and developing countries. Olesen (2009), stated that studies on climate change performed in the last decade across Europe, indicate consistent increases in projected temperature and different patterns of precipitation. The responses he received on the questionnaires used in his study show a surprisingly high proportion of expected negative impacts of climate change on crops and crop production throughout Europe.

Research on climate change and agriculture in developed countries has contributed to investigations in developing countries. In this regard, the International Food Policy Research Institute (IFPRI), together with international and regional organisations – most of which are members of the Consultative Group on International Agricultural Research (CGIAR) – have launched many research studies in order to assess impacts on agriculture and climate change, as well as the risks and challenges faced in Africa and South Africa (Gbetibouo, 2009; Benhin, 2006; Maddison, 2006).

Mendelsohn (2000), states that African agriculture has the slowest record of productivity increase in the world, and experts are concerned that the agricultural sector in the African continent will be especially sensitive to future climate change, as well as any increase in climate variability. The current climate is already marginal with respect to precipitation in many parts of Africa, and although there are well-established concerns about climate change effects in Africa, there is little quantitative information concerning how serious these effects will be.

Midgley *et al.* (2007)[2], mentions that in the report *Impacts, Vulnerability and Adaptation in Key South African Sectors, 2007*, it is stated that modelling studies project a range of possible scenarios and impacts in South Africa, given the uncertainties in global greenhouse gas emissions scenarios and in the response of the climate system. Some of these projected impacts are alarming and are of immediate societal relevance – for example, a projected change in the available water supply in South Africa would have major implications in most sectors of the economy, but especially with regard to urban and agricultural demands. Research studies in this regard are essential.

Many detailed research studies to date have experienced methodological difficulties associated with the quality of climatic and societal data. In the past climatic data was either not available or in many cases not gathered in an acceptable scientific way (Wigley, 1985). This has caused conflict in society because there is sufficient evidence to demand further well-structured investigations as was noted many years ago by Wigley who also states that one of the obfuscating variables in determining the impact, is the adaptability of society to climate stress. The ability to adapt, depends partly on whether or not, and how society perceives climate change. Little work has been done on this aspect in the world (including South Africa) and it would appear to be a fruitful avenue to pursue further – focusing in particular on perceptions and posibilities of adaptation in a specific region.

According to numerous authors (see Gbetibouo, 2009) adaptation is widely recognised as a vital component of any policy response to climate change. Studies show that without adaptation, climate change is generally detrimental to the agriculture sector; however, with adaptation, vulnerability can be reduced largely (Gbetibouo, 2009). In this regard, some research studies shifted the focus of research from the estimation of impacts to the understanding of farm-level adaptation and decision-making. This shift in focus explores actual adaptation behaviour, based on the analysis of farmers' decisions in the face of variable conditions through survey data analysis, indepth interviews, and focus group discussions with farmers and other farm experts, as stated by Maddison (2006).

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[2] Midgley is often referred to as the main author of the publication; therefore reference is made to Midgley *et al.*(2007)

The study *Understanding farmers' perceptions and adaptations to climate change and variability* (Gbetibouo, 2009), in particular, followed a "bottom-up" approach, which intended to gain insight from the farmers themselves. The research methods used, entailed a Heckman Probit Model and a Multinomial Logit (MNL) Model to examine the determinants of adaptation to climate change and variability (Gbetibouo, 2009).

The research results obtained from this study showed that farmers' perceptions of climate change are in line with the climatic data records of the study area namely the Lesotho River basin. According to Gbetibouo (2009), lack of access to credit, was cited by respondents as the main factor inhibiting adaptation. Furthermore, the results of the Multinomial Logit and Heckman Probit Models highlighted that household sizes, farming experience, wealth, access to credit, access to water, tenure rights, off-farm activities, and access to extension are the main factors that enhance adaptive capacity. "Thus, the government should design policies aimed at improving these factors ..." (Gbetibouo, 2009).

Some research studies, however, have taken a different approach by looking at a "top-down" approach by making use of the Ricardian research method. In the study *Climate change and South African Agriculture: Impacts and adaptation options* (Benhin, 2006), it is stated that this approach can be found in spatial analysis and climate impact modelling. The study attempts to assess the economic impact of the expected adverse changes in the climate on crop farming in the country (Benhin, 2006; Anderson *et al*, 2009). It estimates a revised Ricardian Model for South Africa, using farm household crop farming data from selected districts in the nine provinces, long-term climatic data, major soil types in the country, run-off in the districts, and adaptation-related variables such as irrigation, livestock ownership, access to output markets and access to public and other extension services.

According to Benhin (2006), the results showed that climate change affects irrigated farms and dryland farms differently. Furthermore, climate variables, especially for precipitation, have a non-linear relationship with crop net revenues in South Africa. Adaptations such as irrigation, may help reduce the harmful effects of climate change, but if these adaptations are not properly implemented, they may aggravate them (Benhin, 2006). According to Benhin (2006), one significant finding is that there are seasonal differences in the climate effects, and these differences must not be overshadowed by looking only at the mean annual effects. Increased temperatures will be harmful in the summer farming season, but will be beneficial in the winter farming season.

The analysis also shows that the effects of changes in both temperature and precipitation may be different for the different farming systems in the country – irrigated, dryland, large-scale and small-scale farms. Benhin (2006), found that the effects would be different at the provincial levels, and that this finding is important for knowing *how* and *where* to direct the relevant policies for controlling the effects of climate change.

Research has also shown that the abovementioned approaches ("bottom-up and "top-down") can be combined. The study *The perception of and adaptation to climate change in Africa* (Maddison, 2006), is the first analysis of climate impacts and adaptation in the African continent of such scale, and the first in the world to combine cross-country, spatially-referenced survey and climatic data for conducting this type of analysis. Maddison (2006), states that the analyses focus mainly on quantitative assessment of the economic impacts of climate change on agriculture and the farming communities in Africa, based on both the cross-sectional (Ricardian) method and crop response simulation modelling. The cross-sectional analysis also allowed for assessing the possible role of adaptation.

According to Maddison (2006), the objective is to determine the ability of farmers in Africa to detect climate change; ascertain how farmers have adapted to whatever climate change they believe has occurred; determine whether or not farmers perceive any barriers to adaptation; see what attempts have been made to determine the characteristics of those farmers who, despite claiming to have witnessed climate change, have not yet responded to it.

Maddison (2006) stated that the adaptations that were made in response to climate and temperature change included farmers planting different varieties, farmers moving from farming to non-farming activities, farmers practising increased water conservation, and using shading and sheltering techniques.

Maddison (2006), also stated that although large numbers of farmers perceive no barriers to adaptation, those that do perceive the barriers, tend to cite their poverty and inability to borrow. Few (if any) farmers mentioned the lack of appropriate seeds, security of tenure and market accessibility as problems. Those farmers who perceive climate change, but fail to respond, may require particular incentives or assistance to do what is ultimately in their own best interests. Furthermore, adaptation to climate change actually involves a two-stage process: first perceiving that climate change has occurred and then deciding whether or not to adopt a particular measure.

A similar study *An empirical economic assessment of impacts of climate change on agriculture in Zambia* (Jain, 2002*)*, focused mainly on quantitative assessment of the economic impacts of climate change on agriculture and the farming communities in Africa, based on both the cross-sectional (Ricardian) method and crop response simulation modelling. According to Jain (2002), the project employed river-basin hydrology modelling to generate additional climate attributes for the impact assessment and climate scenario analyses, such as surface run-off and stream flow for all districts in the study countries.

The abovementioned research studies indicate how some of the perceptions and adaptation methods to climate change in developing countries (Africa and South Africa) have been investigated. According to Gbetibouo (2009), many agricultural adaptation options have been suggested in the literature.

The adaptation options encompass a wide range of scales (local, regional and global), actors (farmers, firms and government), and types: (a) micro-level options, such as crop diversification and altering the timing of operations; (b) market responses, such as income diversification and credit schemes; (c) institutional changes, mainly government responses, such as removal-preserve subsidies and improvement in agricultural markets; and (d) technological developments and promotion of new crop varieties and advances in water management techniques (Gbetibouo, 2009). Most of these represent possible or potential adaptation measures rather than ones actually adopted. Indeed, there is no evidence that these adaptation options are feasible, realistic, or even likely to occur (Gbetibouo, 2009).

Maddison (2006), stated that from the variety of results and possible solutions obtained, it is unlikely that farmers would know immediately, the best response in dealing with climate change. The Food and Agriculture Organisation of the United Nations predicts that by 2085, 11% of arable land in developing countries could be lost due to climate change, reducing cereal production in more than 65 countries. Looking specifically at Africa, the estimate is that 25 – 42% of habitats could be lost (FAO, 2009). There is sufficient evidence to conclude that African agriculture is very vulnerable to climate change and that it is consequently urgent that studies be undertaken in Africa to estimate the likely magnitude of these effects, as well as to begin to understand adaptation options for Africa and South Africa (Gbetibouo, 2009; Mendelsohn, 2000).

In the report *Impacts, Vulnerability and Adaptation in Key South African Sectors,* (2007) it is noted that both summer and winter rainfall regions in South Africa, face challenges in agricultural production by 2050 (Midgley *et al.,* 2007). Winter rainfall agriculture faces imminent significant threats particularly due to projected increasing water shortages, resulting in greater competition with urban use of water, and lower yields and greater yield variability in both irrigated and rain-fed crops. The result is that many autonomous adaptation options in agriculture already exist, and are simply enhancements of existing risk management or production enhancement activities (Midgley *et al.*, 2005). Midgley *et al.* also stated that where crops are near climate tolerance thresholds, or where multiple stresses exist (for example, soil degradation), or where producers' capacity for autonomous adaptation is exceeded; deliberately planned measures (that is acclimation-type adaptation) will become necessary. The secondary impacts of projected climate changes on the broader, rural and regional economy could be substantial, but have not yet been adequately quantified.

The researchers (Midgley *et al.*, 2005), recognise and introduce the need for two types of adaptation, namely "resilience adaptation[3]", and "acclimatisation-adaptation[4]"; in relation to a changing climate and agriculture in South Africa, as well as a number of potential barriers are introduced to implement adaptation plans. Research on the impact of climate change and agriculture included the use of the ACRU simulation model (Midgley *et al.*, 2005). A further detailed report *A status quo, Vulnerability and Adaptation Assessment of the Physical and Socio-Economic Effects of Climate in the Western Cape* (Midgley *et al.*, 2005) , states that the irrigation sector uses the largest amount of water, and that the biggest benefit, in terms of adaptation, must come from this sector. Irrigation efficiencies must increase dramatically. Farmers in some areas, for example, use very low-efficiency methods for irrigation (flood irrigation from a common furrow). Investment in water resource management should focus on increases in efficiency (demand side) rather than trying to increase the quantity supplied (Midgley *et al.*, 2005).

Risk-averse behaviour is often encouraged by the constraints imposed by the political and institutional arrangements and societal expectations. However, an increasing demand for water from finite sources will progressively lead to decisions that are more responsive to predicted and forecast climatic conditions, and will involve a higher degree of uncertainty and risk, as part of the balances which need to be established (Schultze, 2003).

Decades of "conquering" and developing land and water, including the application of technologies such as dam building or inter-catchment transfers to manage adequate supplies of water for societal and agricultural needs, or solving water quality problems through chemical treatment downstream of waste production (rather than upstream at the source)

3 "The potentially damaging effects of changing climate extremes on sectors." (Midgley *et al*., 2005: 10, 12)

4 "Address strategies to cope with the gradual changes in background climate. These include slow rates of warming that may ultimately require new behaviours and practices in human society." (Midgley *et al.*, 2005: 10, 12)

(Falkenmark, 1999) has left us with a "damaged" ecosystem (Newson *et al*., 2000; as quoted in Schultze, 2003).

Schultze (2003) states that within this "damaged ecosystem", spontaneous regulatory functions of rivers and their catchment areas have been disturbed (for example, through deforestation, increased erosion or dam construction); or removed (for example, by the draining of wetlands). These effects have caused changes in the state of the hydrological system while the manner of exploiting water, and the land from which it is generated, has changed through *intensification of water use* (for example, by irrigation, dryland cropping and urbanisation), as well as other *destruction of traditional exploitation* (for example, by marginalisation of more traditional land use systems and exploitation of marginal lands) – both signifying impacts of human systems. Responses to the damaged ecosystem can be through reactive or proactive responses, which in this case of water resources, imply the integrated management thereof.

A comparative analysis of the World Resources Institute of national action plans addressing climate change in developing countries (India, Brazil, China, Mexico and South Africa), indicates that South Africa is in the process of developing a National Climate Change Response Policy that touches on vulnerability and adaptation (Fransen *et al*, 2009). The release of the National Climate Change Response Strategy (Green Paper) in 2010 underpins that South Africa is indeed in the process developing a policy that will address awareness and adaptation to climate change (DEA, 2010).

On a provincial level, the complex nature of all the possible adaptation solutions resulted in a few areas where policies and programmes have addressed climate change and agriculture in the Western Cape:

1. The government of the Western Cape is currently considering a carbon tax, mainly to boost revenue streams (*Business Day*, 9 March 2005, p5). Government policies, such as carbon taxes, however, may impact on the cost of production and consumption and need to be researched for their environmental effectiveness as well. "It is a new concept in the agricultural sector and as a result there is limited awareness on the opportunities farmers can explore." (Bezuidenhout, 2008).
2. The National Response Strategy to Climate Change, released in November 2010, will have implications on provincial level as well. The National Department of Environmental Affairs (DEA) will, where appropriate, enlist the co-operation of other government departments, provincial and local government, and non-government entities.

3. WWF has a climate change research programme on the resilience of small-scale rooibos tea farmers to climate change. This will serve as a demonstration project with a vision of building a future research programme under WWF and partners, in supporting adaptation to climate change in frontline ecosystems and communities, as well as a number of other projects including climate change in the water sector and adaptation to climate change among marginal groups (Midgley *et al.*, 2005).
4. To bridge the gap between science and policy in addressing global climate change, researchers and government decision-makers met to discuss what they require from the South African Risk and Vulnerability Atlas (SARVA) (*Farmers Weekly*, 31 July 2009, p11). The final product will be a comprehensive storehouse of global change information. Researchers presented six global change case studies to show how the atlas could be used in decision-making. One of the case studies dealt with climate change implications on water and land in the Garden Route agriculture (*Farmers Weekly*, 31 July 2009, p11) which is applicable for the Western Cape.

Areas for further investigation and research still exist in order to address the impact of changes in temperature, evapo-transpiration and rainfall patterns on agricultural practices. The development of new technologies for monitoring atmospheric phenomena offers increasingly efficient instruments in weather forecasting. Meteorological information about atmospheric phenomena such as rainfall, frost, drought, wind and humidity, can be used as a support for various agricultural operations (Predicatori *et al.*, 2008).

Predicatori *et al.* (2008), states that an adequate (and accurate) weather forecast assists in limiting economic and environmental costs (for example, it can reduce the use of irrigation water). The importance of the possible benefits and the surprising interest demonstrated by the farmers for these meteorological themes seems to indicate that a strategy to improve weather forecast services should be supported. Overall, improved weather forecast information and well-trained users would also optimise the use of the natural resources, and in particular, would lead to a better management of water, thus benefitting the whole environment.

When looking at the variety of opinions and possible solutions to climate change and agriculture, it is important to note that *mitigation* deals with the causes of climate change, while *adaptation* tackles its effects. Andersen *et al* (2009), however, argues that in most cases, the effectiveness and the possible negative impacts of the proposed measures are not yet assessed. At the same time it can be stated that proposals, that have the least impact on the attempt to mitigate climate change, can be expected to worsen the situation, as well as have a devastating impact on biodiversity.

The implications of changes in temperature, evapo-transpiration and rainfall patterns on agricultural practices on a national and international level will remain a challenge. To this we should add the insight of Gardiner (2006) who stated that the peculiar features of the climate change problem pose substantial obstacles to the ability of making the difficult choices necessary to address the problem. Climate change, as he formulated it, constitutes “perfect moral storm”. One consequence of this is that, even if the difficult, ethical questions related to climate change mitigation and adaptation could be answered or solved in theory, there may be severe difficulties in acting upon them.

1.4 Methodology

For the purpose of this study, a comprehensive literature review of existing data relating to the implications of changes in temperature, evapo-transpiration and rainfall patterns on agricultural practices was conducted, using accepted scientific methods of research (personal communications, scientific papers, reports, newspaper and web-based data).

The collation of climatic data for the Garden Route, South Africa, as well as liaison with the relevant Government departments and agencies followed the same methods.

The assessment of current agricultural practices in the Garden Route, and the correlation of its results with climate data were made possible by one-to-one meetings with 20 farmers in the Garden Route, the Land Care section of the Department of Agriculture, and representatives from the Agricultural Union. 20 Farmers was decided on due to financial implications. Data was collected and sorted using the attached questionnaire in Appendix A.

The methodology for the second part of this study involved two workshops and a scenario-planning exercise to determine adaptation trends in the observed and projected climate for the Garden Route, with the aim of providing possible solutions for wiser agricultural practices. The following scenarios were compared: (1) If agricultural practices continue as per status quo – with no change in climatic conditions; (2) If agricultural patterns are significantly modified, to reduce agricultural impact on local biodiversity – with no change in climatic conditions; (3) If agricultural practices continue as per status quo – with significant change in climatic conditions; and (4) If agricultural practices are significantly modified, to reduce agricultural impact on local biodiversity, and taking account of likely changes in climatic conditions. The analyses – according to these four scenarios – indicated the likelihood of possible trends in future, using specific climate variables, together with possible adaptation strategies.

The first workshop was held on 15 June 2010 on the Saasveld campus in George. This workshop was held under the leadership of WESSA. This workshop was a follow up action in reference to the survey that was conducted from November 2009 until February 2010. The chairperson was I and minutes were taken by a WESSA representative. Five farmers from the Garden Route region were selected to attend this workshop. The results from the first part of the study were provided beforehand to all the farmers that took part in the survey. This was done in accordance to the terms of reference for this study as set by WESSA. The purpose of the workshop was to provide possible solutions for wiser agricultural practices in the Garden Route, taking the four possible scenarios that the Garden Route area might encounter into account.

The second workshop was held on 20 October 2010 at Kirstenbosch in Cape Town under the leadership of WESSA. The chairperson was once again myself and minutes were taken by a WESSA representative. A panel of specialists (agricultural economists, a climatologist, a biologist and a sociologist[5]) were invited according to criteria set by WESSA. These specialists reviewed and gave input to the comments of the farmers obtained during the first workshop. The specialists gave their recommendations to farmers, relevant government departments and politicians, taking the above-mentioned scenarios into account. The results were summarised according to four main categories, namely: (1) climate and water usage, (2) alien management considerations, (3) adaptation (short and long term), and (4) research and future considerations.

1.4.1 Survey data

The study collected a large range of data. Ethical clearance was obtained from the University of Stellenbosch together with permission from the Wildlife Society of South Africa (WESSA) to conduct this research and use results in this study (refer to Appendix B). The study examined how farmers' interpretations of weather conditions have corresponded with the climate data recorded at various meteorological stations in the Garden Route region as portrayed as the "study area" in Figure 1.3. The study also analysed farmers' adaptive responses to, perceptions of, and possible barriers regarding climate change. The survey consisted of closed–ended questions (with default in methods of response) and open–ended

[5] Mr Martin de Wit (environmental and resource economist: Sustainable Options), Dr G. Midgely (climatologist: SANBI), Dr. S. du Toit (biologist: WESSA) and Ms L. Pasquini (sociologist: UCT).

questions (with free answers). Univariate comparisons formed part of the analyses. Annexure A displays the exact formulation of the questions. Personal data has remained anonymous.

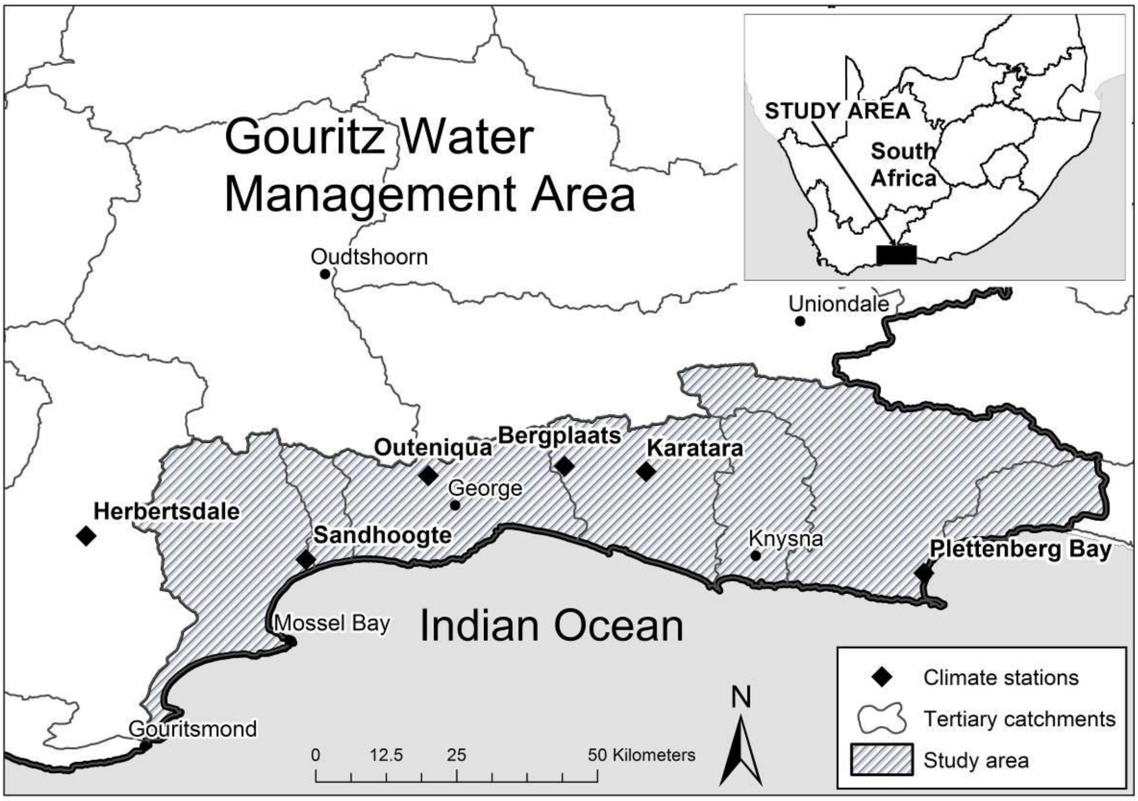

Figure 1.3: Climate stations in the Garden Route area

The period in which this survey was conducted, was from November 2009 to February 2010. In total, 20 farmers (hereinafter referred to as “the farmers”), were individually visited and 20 surveys were completed. These famers were randomly selected based on contact details that were obtained from the famers Union. They were contacted telephonically, I explained the project and they were selected on the basis that they were willing to take part in the survey. Interviews during this study were open–ended discussions in relation to questions asked, as well as ethical issues that were important in their daily actions on their farms. Interestingly, a common reaction of most of the farmers when asked to identify ethical challenges related to climate change, was that they would get a grin on their face, as if they had a story to tell about some ethical issue or problem they have observed, or have had to deal with. All of the farmers interviewed were quite willing to talk about ethics. The most common theme that arose during the interviews was the growing industrialisation of agriculture, climate change and the economic realities it produces. In fact, when asked to describe what they thought were the most important ethical issues in the farming sector of the Garden Route, nearly every farmer gave as their first illustration some behaviour, often not ethically acceptable, that can be linked to water availability and security. As one farmer observed: "You do what you have to do"*.*

1.4.2 Meteorological data

Monthly precipitation and temperature data were obtained from the CSIR (Cape Town). The data reflects the period from January 1967 to December 2008.

1.4.3 The Heckman Probit Adaptation Model and other statistics

The survey results were analysed in cooperation with Professor M Kidd from the Centre for Statistical Consultation (CSC) at the University of Stellenbosch. Univariate comparisons formed part of the analyses of the closed answers (Refer to Annexure C). Furthermore the Heckman Probit Adaptation Model was applied to determine the likelihood of perceiving any change in the climate as well as the likelihood of farmers' adapting to these changes. The dependent variable for the selection equation is binary indicating whether or not a farmer perceives climate change; the dependent variable for the outcome equation is also binary indicating whether or not a farmer responded to the perceived changes by adapting farming practices. The dependent variable for the *selection* equation is binary, indicating whether or not a farmer perceives climate change. The dependent variable for the *outcome* equation is also binary, indicating whether or not a farmer responded to the perceived changes by adapting his or her farming practices. The likelihood function for the Heckman Probit Adaptation Model was significant where $P<0.005$.

1.4.4 Applied ethics

According to Robert Heeger (1992), four central tasks can be distinguished in "applying" ethics to moral problems. Aspects of all four of these tasks were incorporated in this thesis.

1. The primary task of ethics is to respond to a growing constraint to which society is subjected. This entails the challenge to make moral decisions. From this angle, ethics deal for instance, with problems caused by the progress of science and technology, or by the difference between the poor and the rich. These problems are real and not invented to illustrate an ethical theory.
2. A second task of ethics is to analyse the moral features of these problems and to employ its concepts and theories to try to find acceptable solutions.
3. In order to do this, a third essential task of ethics and ethical analysis is to work with empirical questions so that the researcher knows enough about the specific area in which an ethical problem emerges to find satisfactory solutions.

4. A fourth task is for ethics, related to the third task mentioned above, to place its theories in interaction with the context of their application. It does not simply apply its theories, but permits that questions of application react on the theories and that the theories may thereby be adjusted.

1.4.5 Structure of thesis

Chapter 1 provides the introduction and objective of this thesis in which the relevance of the study from a climate change perspective is discussed. An outline of the methodology applied during this research is provided that explains the methods that were used in order to gather data for this thesis.

Chapter 2 provides an analysis of the results obtained from the survey conducted during 2010 and 2011 in the Garden Route. 20 Farmers were visited in the region and information was obtained through in-depth interviews and discussions.

Chapter 3 discusses the differences between the climatic data obtained from the CSIR and the results of the perceptions of farmers in reference to the climatic data, as well as the reasons for these differences. An analysis of the views and experiences of farmers with regard to temperature change (maximum and minimum), rainfall patterns and extreme events is provided. Furthermore, adaptation methods based on the experience of farmers and future considerations are explored.

Chapter 4 provides the results of the Heckman Probit Model. Although a large percentage of the farmers that were interviewed did observe changes in the climate, they did not always take remedial action. Six independent variables were included in the Model to determine their experience of climate change. The following questions were probed:

Is there, among the surveyed farmers, a relationship between their perceptions (experience) of climate change occurence using explanatory variables such as:

- Water Management Association Membership
- Conservation farming
- Organic farming
- Irrigating larger areasto those farmers who irrigate smaller areas
- Years of farming experience
- Education

Furthermore, results are provided of the farmers who actually adapted to climate change according to the list of independent explanatory variables. In this regard, the following questions were probed:

- Is there, among the surveyed farmers, a relationship between farmers belonging to a Water Management Association, and adaptation to climate change?
- Is there, among the surveyed farmers, a relationship between farmers who irrigate larger areas, and adapt to climate change; to those farmers who irrigate smaller areas and their adaptation to climate change?
- Is there, among the surveyed farmers, a relationship between farmers who have more years of farming experience and adaptation to climate change; to those farmers with fewer years of farming experience, and adaptation to climate change?

Chapter 5 provides a discussion of the results of the survey and the Heckman Probit Model.

Chapter 6 discusses the scenario planning exercise that was conducted after the analysis of the data obtained during the survey. A workshop was held at Saasveld (George) and five farmers from the Garden Route region were selected to attend this workshop. The purpose of the workshop was to provide possible solutions for wiser agricultural practices in the Garden Route, taking the following scenarios into account. The following scenarios were compared: (1) Agricultural practices continue as per status quo–with no change in climatic conditions; (2) Agricultural patterns are significantly modified, to reduce agricultural impact on local biodiversity–with no change in climatic conditions; (3) Agricultural practices continue as per status quo–with significant change in climatic conditions; and (4) Agricultural practices are significantly modified, to reduce agricultural impact on local biodiversity, and taking account of likely changes in climatic conditions. A second workshop was held at Kirstenbosch (Cape Town) where a panel of 4 specialists (an agricultural economist, a climatologist, a biologist and a sociologist[6]) reviewed and gave input to the comments of the farmers obtained during the first workshop. Recommendations and a possible project to launch in order to address climate change adaptation and the limited water resources in the Garden Route were discussed.

Chapter 7 discusses and summarizes the moral issues as experienced by the farmers of the Garden Route in reference to the results of the survey, the results of the Heckman Probit Adaptation Model and issues raised pertaining to water management in the area.

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[6] Refer to footnote 5 for credibility.

CHAPTER 2: **RESULTS OF THE SURVEY**

During November 2009 until the end of February 2010, a survey was conducted in the Garden Route region where a total of 20 farmers were individually visited and 20 surveys were completed (Refer to Figure 2.1). All the results of this survey are provided in this chapter. The data that was collected is presented in short paragraphs and relates directly to the questionnaire in Annexure A. This questionnaire was formulated and compiled in consultation with the Centre for Statistical Consultation (CSC) of Stellenbosh University. The results of each question are portrayed below. The interpretations of these results are discussed in Chapter 5.

2.1 Information about farms

The physical location of farms visited for the purpose of this study in local municipal areas, reflect the following: 65% were located within the George municipal area, 20% within the Mossel Bay municipal area and 15% within the Knysna municipal area (See Figure 2.1).

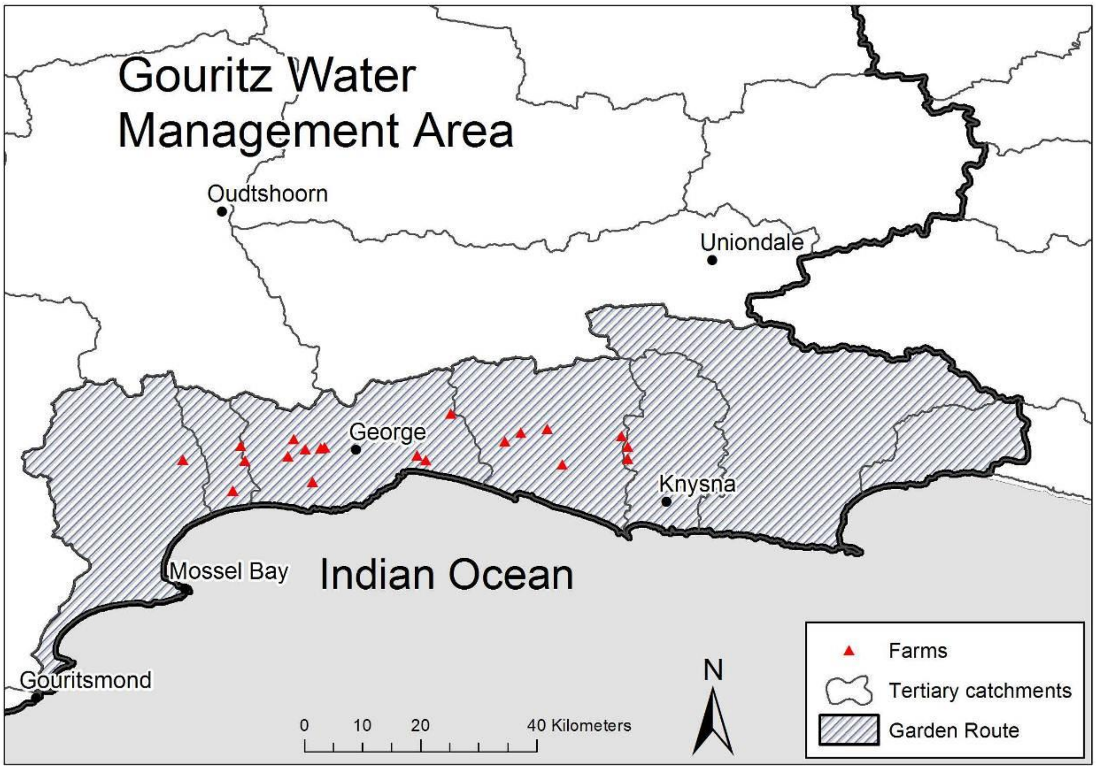


Figure 2.1: Farms visited during the survey period between November 2009 and February 2010

The following results indicate the percentages of farmers affiliated to farmers' associations: 10% indicated that they are not part of any farmers' association. 35% indicated that they are part of the George Farmers' Association. 20% indicated that they are part of the Outeniqualand Farmers' Association. 35% indicated that they are part of the Knysna Farmers' Association.

The following results indicate the percentages of farmers affiliated to Water Management Associations: 50% indicated that they do not belong to any Water Management Association. 20% indicated that they belong to the Maalgate Water Management Association. 5% indicated that they belong to the Sedgefield and Wilderness Lakes Forum. 15% indicated that they belong to the Sedgefield Water Forum. 10% indicated that they belong to the Knysna Water Forum.

90% of the farmers indicated that they own their farms. 10% of the farmers indicated that they were renting the farms.

The types of farming represented in the sample are as follows: dairy and beef cattle (55%); vegetables (25%); fruit (15%); other (5%).

Figure 2.2: Jersey cows grazing on kikuyu rye grass in the Garden Route area

100% of the farmers have access to water. The following percentages represent the forms or sources of water that these 20 farmers currently have access to on their farms: off-stream dams (75%); dams affecting a river course (25%); boreholes (40%); “Leibeurt” (15%).

Current water quota resulted as follows: 35% of the farmers chose not to comment on their current water usage (water allocation / water quota).

Farmers were asked to indicate the area (ha) under irrigation on their farm(s). See Figure 2.3[7]. Farmers were also asked to indicate the area (ha) of dry land on their farm(s). See Figure 2.4[8].

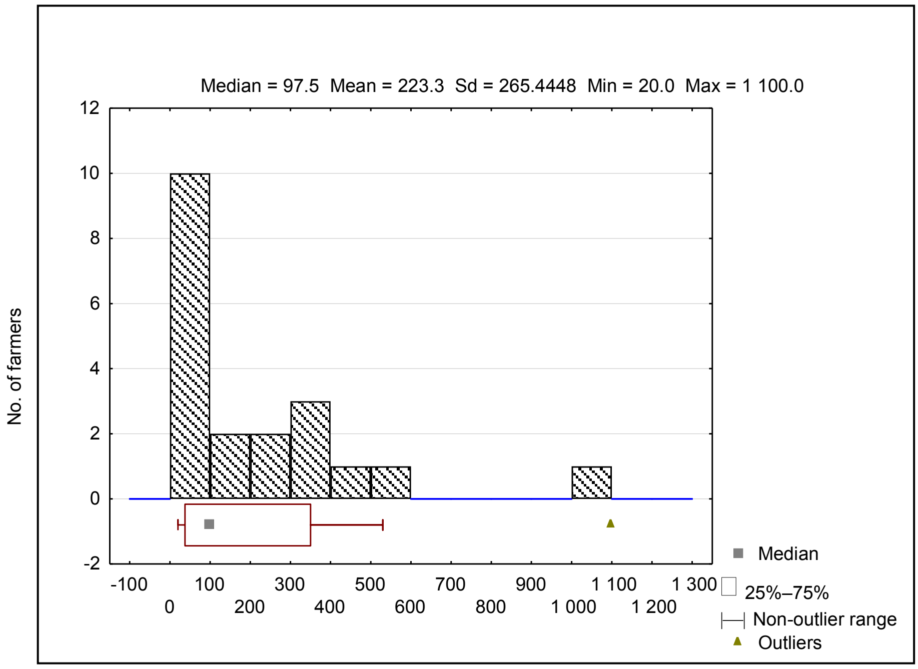


Figure 2.3: Area(s) under irrigation (ha)

[7] **Note:** “non-outlier range” and “outliers” refer to the following: with a box plot there is a specific standard formula for calculating the non-outlier range. The purpose is to identify points that lie “far” away from the rest of the data.

[8] **Note:** “non-outlier range” and “outliers” refer to the following: with a box plot there is a specific standard formula for calculating the non-outlier range. The purpose is to identify points that lie “far” away from the rest of the data.

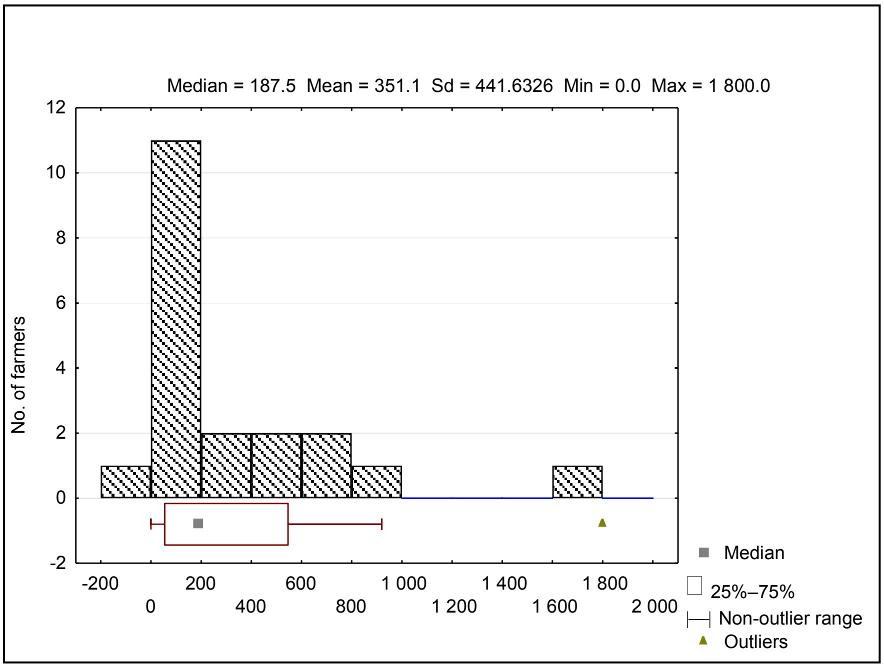


Figure 2.4: Area(s) dry land (ha)

2.2. Biographical information and perception of climate change

100% of the farmers interviewed were males. 20% of the farmers have between 40–50 years farming experience. 50% of the farmers have between 20–30 years farming experience. 25% of the farmers have between 10–20 years farming experience. 5% of the farmers have between 0–10 years farming experience.

25% of the farmers obtained Grade 12. 60% of the farmers obtained a first university degree. 25% of the farmers obtained a postgraduate university degree.

2.3 Climate

Farmers were asked how often they make use of the television, radio, internet, newspaper or any other source to obtain information about the weather forecast (Table 2.1). The results showed that 100% of the farmers rely on the internet for the most accurate information. The most commonly-used websites include: www.windfinder.com, www.windguru.com (American), www.wn.com (Norwegian), wxmaps.org, www.findlocalweather.com (Danish), and www.weathersa.co.za (South African).

Table 2.1: Information sources used to obtain weather forecast

		OFTEN (weekly)	SELDOM (monthly)	NEVER
1.1	Television	30%	20%	50%
1.2	Radio	10%	20%	70%
1.3	Internet	100%		
1.4	Newspaper	15%	20%	75%
1.5	Other (Please specify)	10%	10%	80%

65% of the farmers obtained information on climate change, as well as information on measures to adapt to climate change. 35% of the farmers indicated that they had not obtained any information on climate change.

The farmers who had obtained information, indicated that the farmer union workshops offered in the Garden Route area were the most informative; however, the greatest factors influencing their attendance were the financial costs incurred to attend the workshop and their absence on the farm with cost effects, as well as the time needed to attend these workshops.

90% of the farmers rely on meteorological information in conducting their farming activities. Farmers placed great emphasis on the need for accurate weather predictions.

Farmers were asked which weather services they made use of in order to obtain their meteorological information (Table 2.2). 100% of the farmers make use of the National weather bureau (SA Weather Bureau).

25% of the farmers make use of the Regional meteorological service (Outeniqua Experimental Farm). 20% of the farmers make use of local, private meteorological stations on their farms. 15% of the farmers make use of the media (newspapers). 30% of the farmers make use of other sources (neighbours and own analyses).

Table 2.2: Services used to obtain meteorological information

	YES	NO
2.1 National weather bureau (SA Weather Bureau)	100%	
2.2 Regional meteorological service	25%	75%
2.3 Local private meteorological services	20%	80%
2.4 Media (Television and newspapers)	15%	85%
2.5 Other (Please specify)	30%	70%

Farmers were asked if an improvement in weather forecast services would benefit the following aspects pertaining to farming: (1) Fungicide treatment, (2) insect control, (3) weed killer treatment, and (4) irrigation. 100% of the farmers indicated their crops would benefit from fungicide treatment. 100% of the farmers indicated it would benefit insect control. 90% of the farmers indicated it would benefit from weed killer treatment. 95% of the farmers indicated it would benefit the farmer to schedule the irrigation programme.

2.4 Irrigation

Figure 2.5: Ryegrass pastures with the Outeniqua Mountain

Farmers were asked if they consider the choice of an irrigation system as a strategy to adapt to climate change. 70% of the farmers indicated “Yes” and 30% of the farmers indicated “No”. The farmers also stated that technology influenced their decisions around changing their irrigation systems.

55% of the farmers indicated that they currently make use of irrigation advice, of which these farmers obtained advice from private consultants. 45% of the farmers do not make use of irrigation advice.

The farmers were asked what kind of irrigation systems they use. Depending on the type of farming, farmers make use of pivot systems, drip irrigation and quick draglines. Farmers who use the pivot irrigation system stated that it is an efficient method and it wastes less water. Farmers, who use the drip irrigation, stated that they could cover a larger area (ha), and still use the same amount of water to irrigate their crops.

Figure 2.6: Centre pivot irrigation

2.5. Observation of conditional changes and adaptation

2.5.1 Observation of changes (diverse changes)

Only 5% of the farmers observed a reduction in their crop yields to a large extent (Figure 2.7). 15% of the farmers observed a reduction in their crop yields to some extent. 15% of the farmers observed a reduction in their crop yields to a little extent. 65% of the farmers did not observe a reduction in crop yields at all.

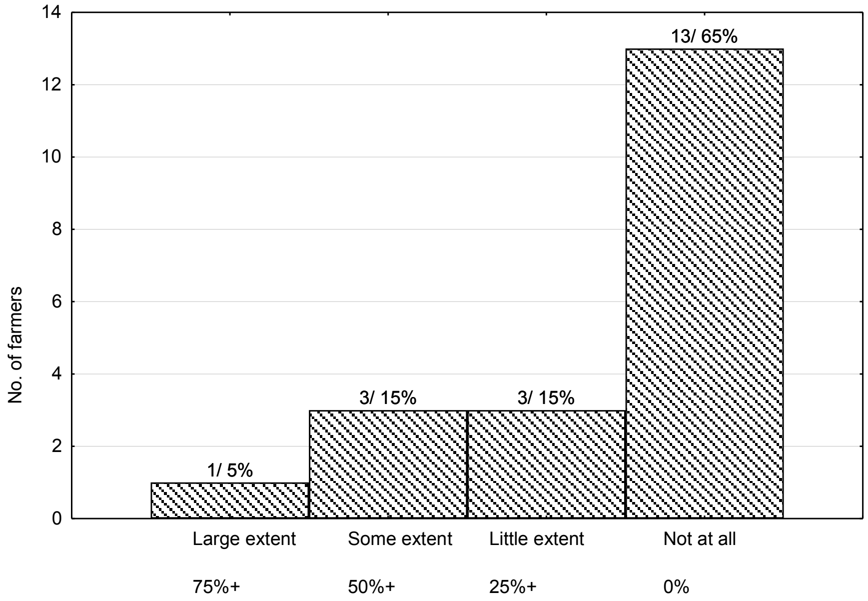


Figure 2.7: Observation of reduction in crop yields over the years

5% of the farmers observed an increase in the incidences of pests to a large extent. 25% of the farmers observed an increase in the incidences of pests to some extent. 55% of the farmers observed an increase in the incidences of pests to a little extent. 15% of the farmers did not observe an increase in the incidences of pests at all.

10% of the farmers observed an increase in the incidences of diseases to a large extent. 15% of the farmers observed an increase in the incidences of diseases to some extent. 30% of the farmers observed an increase in the incidences of diseases to a little extent. 45% of the farmers did not observe an increase in the incidences of diseases at all.

50% of the farmers (Figure 2.8) experienced a change in the availability of water (due to climatic factors) to a large extent. 20% of the farmers experienced a change in the availability of water (due to climatic factors) to some extent.

10% of the farmers experienced a change in the availability of water (due to climatic factors) to a little extent. 20% of the farmers did not experience a change in the availability of water (due to climatic factors) at all.

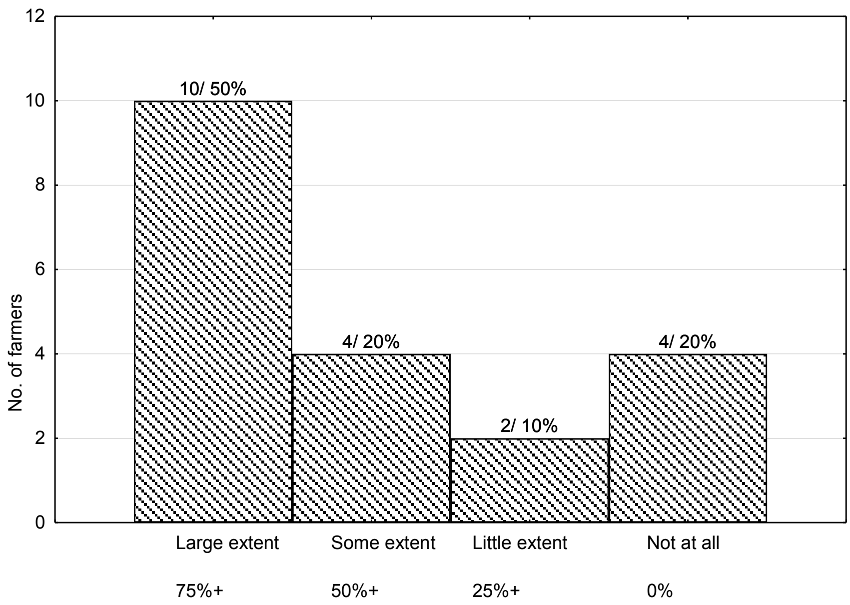


Figure 2.8: Percentage of farmers who experienced a change (less) in the availability of water due to climatic factors

15% of the farmers experienced a change in the availability of water (due to a change in the water quota) to a large extent. 15% of the farmers experienced a change in the availability of water (due to a change in the water quota) to some extent. 10% of the farmers experienced a change in the availability of water (due to a change in the water quota) to a little extent. 60% of the farmers did not experience a change in the availability of water (due to a change in the water quota) at all.

20% of the farmers experienced a reduction in soil fertility (due to a change in rainfall) to a little extent. 80% of the farmers did not experience a reduction in soil fertility (due to a change in rainfall) at all.

2.6 Observation of temperature changes

35% of the farmers indicated that they observed[9] an *increase* in the maximum temperatures over the years. 5% of the farmers indicated that they observed a *decrease* in the maximum temperatures over the years. 60% of the farmers indicated that they have *not* observed a change in the maximum temperatures over the years.

[9] Some farmers measured these increases and others observed the increases through weather forecasts.

The following percentages represent the totals within the "sub-group" (35%) of farmers that noticed an increase in the maximum temperatures. Of the 35% (seven) of the farmers who observed an increase in the maximum temperatures, 10% (two farmers) made this observation during the period of 1980–1989, 25% (five – including the first two farmers) made this observation during the period of 1990–2000, and 35% (all seven farmers) made this observation during the period of 2000–2009. 35% of the farmers observed an *increase* in the maximum temperatures over the years.

85% of the farmers indicated that they observed an *increase* in the minimum temperatures over the years. 5% of the farmers indicated that they observed a *decrease* in the minimum temperatures over the years. 10% of the farmers *did not* observe a change in the minimum temperature over the years at all.

The following percentages represent the totals within the "sub-group" (85%) of farmers that noticed an increase in the minimum temperatures.

Of the 85% (17) of the farmers who observed an increase in the minimum temperatures; 50% (ten farmers) made this observation during the period of 1990–2000, and 85% (all 17 farmers) made this observation during the period of 2000–2009.

85% of the farmers who observed an increase in the minimum temperatures, indicated the months represented in Figure 2.9.

Note: 80% of the 85% of farmers observed an increase in the minimum temperature over the months April, May and June; 75% of the 85% over February; 70% of the 85% over January, March and July; 60% of the 85% over August, September, October, November and December.

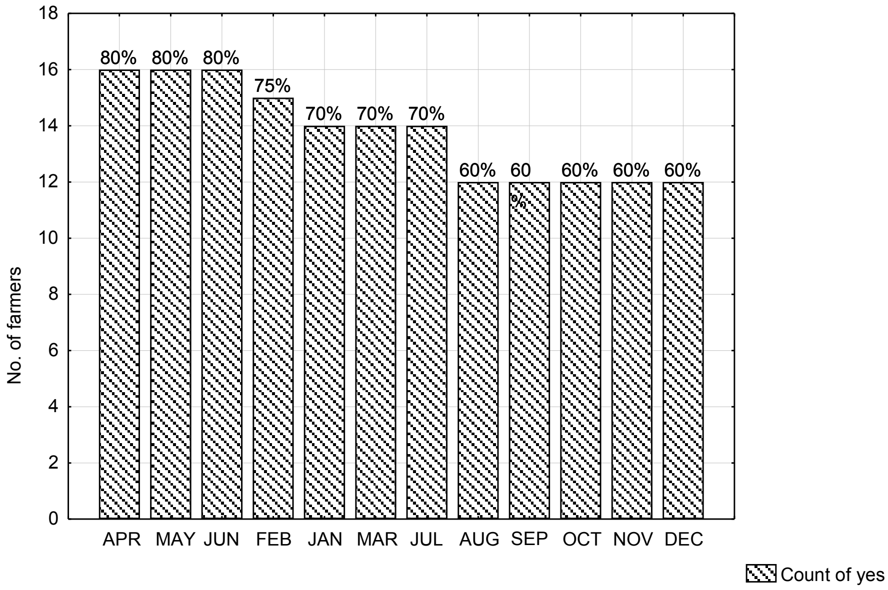


Figure 2.9: Percentage of farmers who observed an increase in the minimum temperature during certain months of the years

50% of the farmers observed an *increase* in the number of very hot (extreme) days. 5% of the farmers observed a *decrease* in the number of very hot (extreme) days. 45% of the farmers *did not* observe a change in the number of very hot (extreme) days at all.

Of the 50% of the farmers who observed an increase in the number of very hot days; 50% made this observation during the period of 1990–2000, and 85% made this observation during the period of 2000–2009.

50% of the farmers observed an increase in the number of very hot days over the years.

2.7 Views on temperature change (maximum and minimum)

Farmers were asked whether or not the change in temperature would be a factor to consider when planning future agricultural practices. 70% of the farmers felt that there is a slow, overall increase in temperature. Farmers also mentioned that the change in temperature influences the choice of varieties and cultivars for future planning.

The increase of temperatures increases the rate of evaporation. Farmers placed great emphasis on the importance of suitable irrigation and irrigation techniques.

Figure 2.10: Irrigated vegetable farm with centre pivot and sprinkler system

Farmers were asked in what way they perceive the maximum and minimum temperatures to change in the future (next 30 years).

50% of the farmers indicated that in future, the trend of a general increase of temperature would continue. In order to adapt to the temperature increase, 45% of the farmers mentioned that they should purchase feed from other regions.

Farmers relying on grazing should consider storing more feeds for animals. 40% of the farmers indicated that the maximum and minimum temperatures follow a trend of both warmer and cooler periods; however, they were currently experiencing a warmer period.

According to these farmers, the possibility exists that a cooler period might occur in 30 years from now. 15% of the farmers indicated that they had no comment with regard to the prediction of future temperatures.

Figure 2.11: Kikuyu, ryegrass and clover pastures

2.8 Observation of changes in rainfall

75% of the farmers observed a *decrease* in rainfall over the years. 10% of the farmers observed an *increase* in rainfall over the years. 15% of the farmers *did not* observe a change in rainfall over the years at all.

Of the 75% of the farmers who observed a decrease in rainfall; 5% made this observation during the period of 1960–1969, 5% made this observation during the period of 1970–1979, 30% made this observation during the period of 1980–1989, 70% made this observation during the period of 1990–1999, and 100% made this observation during the period of 2000–2009.

75% of the farmers who observed a decrease in rainfall indicated that they made this observation mainly during June, July, August and September.

100% of the farmers considered the distribution of rainfall to have become more erratic in recent years.100% of the farmers indicated that they have not experienced any improvement in the distribution of rainfall in recent years.

2.9 Views on changes in rainfall patterns

Farmers were asked in what way do they foresee that the rainfall patterns will change in future (in the next 30 years). 100% of the farmers indicated that the rainfall pattern has changed. 50% of the farmers predicted that erratic rainfall patterns would continue. 35% of the farmers indicated that they are currently experiencing a dry period, and that in future, they predict further wetter and drier periods would occur. According to this 35% of the farmers, there is a possibility that there could be a wetter period (as opposed to a drier period) in 30 years from now. 15% of the farmers indicated that they had no comment with regard to the prediction of future rainfall patterns.

Farmers were asked whether or not they consider a change in the rainfall to be a factor when planning future agricultural practices. 100% of the farmers indicated that there is a change in the rainfall pattern and that rainfall had become more erratic. Most farmers formulated the change in the rainfall as an increasing variability.

Farmers mentioned that the change in rainfall made it difficult when planning future agricultural practices. Farmers emphasised the need to obtain permission to increase storage and dam capacity (more dams and higher dam walls).

The current political situation (BEE contracts) was mentioned as a barrier in this regard; it influences the choice of varieties and cultivars for future planning. Due to the change in rainfall patterns, the importance of irrigation and irrigation techniques were highlighted by farmers.

2.10 Observation of extreme events (floods, fire, droughts and wind)

75% of the farmers observed an increase in flood events during the years. 25% of the farmers observed no change in the occurrence of flood events. 30% of the farmers observed an increase in fires during the years. 5% of the farmers observed a decrease in fires during the years.

65% of the farmers did not observe a change in the occurrence of fires at all. 80% of the farmers observed an increase in occurrence of droughts during the years. 20% of the farmers did not observe a change in the occurrence of droughts.

Figure 2.12: The Garden Route dam at 26% during a drought period between 2009 and 2010

85% of the farmers observed an increase in extreme wind conditions during the years. 5% of the farmers observed a decrease in extreme wind conditions during the years. 10% of the farmers did not observe a change in the occurrence of extreme wind conditions.

Only 25% of the farmers have an insurance policy that covers the risk of a contingent loss caused by any extreme event (drought, flood, fire and wind). 75% of the farmers have no insurance policy. Farmers indicated that due to the high-risk nature of the insurance cover, the insurance premiums are very expensive. However, in some cases, policies (for example, insurance against drought), do not exist.

2.11 Views on extreme events

Farmers were asked: in what way do they foresee that the extreme weather events will change in future (in the next 30 years). 50% of the farmers predicted that the trend of an increase in floods, recurrent droughts and extreme wind conditions would continue. 35% of the farmers predicted that extreme events are conditional and follow a trend of cycles; they indicated however, that they are currently experiencing a high intensity cycle of extreme events. According to this 35% of the farmers, it is possible that there could be a less intense cycle of extreme events in 30 years from now. 15% of the farmers indicated that they had no comment with regard to the prediction of extreme weather events.

Farmers were asked whether or not they regard the possible increase in extreme events as a factor to consider when planning future agricultural practices. 90% of the farmers indicated that they do consider the increase in extreme events to be a factor, when planning future agricultural practices. Extreme events were mostly noted to be droughts and floods. These farmers mentioned that the increase in extreme events made it difficult when planning for future agricultural practices. Farmers mentioned that the amount of financial support and advice from official structures has proven to be a barrier when assisting with flood damage and drought. Farmers indicated that the rights to increase their water storage capacity on their farms, especially due to the increase in flood events were seen as a barrier. Farmers also mentioned that it is possible for the area to become drier in future and they would need to make the necessary adaptations such as changing their farming practices. However, most farmers indicated that they would like to carry on with their current farming practices.

2.12 Adaptation (based on experience: temperature, rainfall, extreme events and type of farming)

90% of the farmers indicated that they have made adjustments in their farming activities according to their long-term perception and experience of temperature, rainfall and extreme events. 10% of the farmers made no adjustments.

Farmers were asked to identify the factors influencing their changes to their farming activities, according to their long-term perception and experience of temperature, rainfall and extreme events. Farmers indicated that their own experience was a primary factor (flood events, droughts, change in rainfall pattern and an increase in wind). The second factor was the advice they had obtained from experts and at workshops. The third factor was the pressure they had received, from the market, to use less chemical fertiliser in their farming methods.

Farmers were asked to identify the main constraints in changing their ways of farming. The following constraints were raised: (1) Obtaining rights to increasing their water storage capacities (increasing dam walls or building dams); (2) flood water management; (3) cash flow and financial support; (4) obtaining permits to burn; (5) general support from official structures.

2.13 Adaptation and future considerations

Farmers were asked which of the following measures (Table 2.3) they would consider in future, and which they have already implemented, and when. Reasons for adaptation varied. Technology, market and influencing weather conditions were mentioned as the most significant reasons.

Table 2.3: Adaptation and future considerations

		Consider in future	Implemented	None
3.1	Change crop variety.		85%	15%
3.2	Automated irrigation.	5%	95%	
3.3	Implement soil conservation techniques.	25%	65%	10%
3.4	Buy insurance or insure your farm.	15%	20%	65%
3.5	Reduce number of livestock.	10%	45%	45%
3.6	Lease your land.	10%	5%	85%
3.7	Find off-farm job.	10%	5%	85%
3.8	Build a water-harvesting facility.	5%	90%	5%
3.9	Change amount of arable land.	30%	55%	15%
3.10	Change planting date.	15%	65%	20%
3.11	Livestock feed supplements from off-farm.		65%	35%
3.12	Resort to more heat tolerant breeds rather than traditional ones.		65%	35%
3.13	Change the timing, duration and location of grazing.	10%	45%	45%
3.14	Increase application of chemicals (such as Erian) to slow down evapo-transpiration.		20%	80%
3.15	Apply more organic fertilisation to retain moisture content and fertility of soil.	5%	75%	20%
3.16	Keep the crop residues of the previous harvest on the land to preserve soil moisture, cool the soil surface and stabilise soil temperature.	10%	80%	10%
3.17	Sink your own borehole(s).	30%	40%	30%
3.18	Make use of a floodplain for agricultural production.		15%	85%
3.19	Use credit to buy new technology.	10%	25%	65%
3.20	Other[10]	5%	15%	80%

2.14 Utilisation of rivers

15% of the farmers needed to influence the course of the river by means of erecting berms (artificial ridges acting as little walls in the course of a river), or otherwise in order to protect their crops against floods. None of the farmers had been advised to remove silt from the river after a flood event.

[10] No specifications were made under the heading “Other”

Figure 2.13: An example of a structure built in the river to rehabilitate the river channel

Figure 2.14: A deep incised river channel with farming activities on the river bank, making farmers vulnerable to flooding and erosion

2.15 A quest for solutions (river utilisation)

Farmers were asked if the change in climate contributed to any possible farming activities in floodplains of rivers, occurring on their farms. 90% of the farmers indicated that the change in climate does not contribute to agricultural activities in the floodplain of rivers; 10% of the farmers indicated that the change in climate contributed to agricultural activities in the floodplain of rivers.

Farmers were asked if they had considered the option of organic farming (or currently practise organic farming), as well as listing any constraints relating to organic farming. 35% of the farmers indicated that they currently practise organic farming and that the local and overseas (export) market is their main reason for this farming method. 20% of the farmers indicated that the terms "organic farming" and "conservation farming", appear to be very similar in practice. These farmers indicated that organic farming entails the form of agriculture that relies on crop rotation, green manure, compost, biological pest control, and mechanical cultivation to maintain soil productivity.

Pest control, excluding or strictly limiting the use of synthetic fertilisers and synthetic pesticides; plant growth regulators; livestock feed additives; genetically modified organisms, all form part of organic farming practice. Farmers underlined that conservation farming includes many of these factors. 45% of the farmers indicated that they perceive organic farming to be a "label" in order to sell a product, and that the quality of products does not really differ much from other products produced through conservation farming. These farmers mentioned that organic farming does not provide food for the majority of the population; the prices of organic products can only be afforded by a very small percentage; thus still leaving us with the question of how to approach the food demand of the "general", greater society. Farmers also indicated that organic farming is not a logical equation option, due to the fact that it is limited to certain markets, not always viable and that farmers struggle with inputs in order to sustain a yield.

Farmers were asked if they had considered the option of conservation farming (or currently practise conservation farming), as well as listing the constraints relating to conservation farming. 45% of the farmers indicated that they currently practise conservation farming and that some of them are still in the process of changing to this particular farming method.

According to these farmers, conservation farming consists of three components namely: no or minimum till, retention of plant stubble on the land, and crop rotation with various crops. The soil is not ploughed if there is no, or minimum till. Instead of ploughing and sowing, the seed and fertiliser are sowed directly in the stubble of the previous crop. This is done with an implement that has steel teeth or blades instead of traditional ploughshares. The teeth make a furrow in the soil, into which the seed and fertiliser are placed. The furrow closes upon itself after the tooth has moved on. No till prevents degradation of soil structure since the soil is not ploughed and pulverised. The fertiliser and seed are directly put into the furrow in the soil, at the correct depth for the crop in question. In other words, the soil is only worked once, reducing the cost of cultivation. The stubble also prevents evaporation of the moisture in the soil and the moisture will then be used for the degradation of organic material in the soil, which has an enriching effect. Earthworms can live in the soil in these conditions, and will help in the degradation of organic material.

Crop rotation refers to the cultivation of different crops on a specific piece of land; in other words, the same crop will not be cultivated every year. By rotating crops, the soil will not be exhausted and gets the opportunity to recover. Crop rotation also means that crops which place nitrogen back into the soil, such as soya or beans, will be part of the crop rotation programme. This saves on the use of fertiliser.

Farmers indicated that the changeover from conventional farming to conservation farming can be very expensive, in terms of specialised planting equipment and completely new dynamics of conservation farming systems – both of which require high management skills and a learning process for the farmers (perhaps the reasons that have prevented some farmers from switching over prior to this).

2.16 Soil and water conditions on farms

80% of the farmers indicated that the soil on their farms consists of sand and clay (duplex) and has a low degree of aggregation; 20% did not agree with the statement that soil consists of sand and clay (duplex) and has a low degree of aggregation. This is to measure the characteristics of the soil.

40% of the farmers felt that there was an increase in root disease and nematodes; 15% were neutral; 45% did not agree that there was an increase in root disease and nematodes.

35% of the farmers agreed that the occurrence of algae in water has increased; 20% were neutral; 45% did not agree that algae in water have increased.

65% of the farmers agreed that there is less surface water and ground water recharge; 20% were neutral; 15% did not agree that there is less surface and groundwater recharge.

2.17 A quest for solutions (water and soil)

70% of the farmers agreed that integrated water resource planning should form part of daily practice (for example, investigate water re-use and the integration of resources such as groundwater, surface water and rainwater capture); 25% were neutral; 5% did not agree that integrated water resource planning should form part of daily practice.

60% of the farmers agreed that an advisor should form part of a management team on a farm; 20% were neutral; 20% did not feel that it was necessary.

60% of the farmers agreed that realistic setback lines should be determined for agricultural practices around rivers, floodplains and wetlands; 35% were neutral; 5% did not agree that setback lines should be determined.

Figure 2.15: Ecologically sensitive peat wetlands with farming activities in the floodplain

40% of the farmers agreed that artificial wetlands should be created to protect floodplains; 45% were neutral; 15% did not agree that artificial wetlands should be created. 50% of the farmers agreed that a revision of water allocations (quotas) for farms is necessary; 35% were neutral; 15% felt that it was unnecessary.

Farmers were asked to list their main constraints with regard to the eradication of alien plants on their farms. 90% of the farmers indicated that it is necessary to remove alien vegetation; however, time and financial implications are their main constraints. 10% of the farmers indicated that it makes no difference to their current agricultural practice and water usage, by removing alien vegetation. Farmers also indicated that the “Work for Water Programme” is a good initiative; however, the work should be done on a continual basis where the Work for Water team needs to do follow up visits to farms.

Figure 2.16: Alien invasive vegetation and farm land encroaching on a Garden Route river

Farmers indicated that removing alien vegetation such as the blackwattle trees, should result in changing the volume of run-off in rivers. However, these farmers also stated that it can be a difficult task to remove these trees, due to the topography and accessibility of certain areas. Some farmers indicated that it is an ethical challenge for each farmer to remove alien vegetation on their own property, due to the fact that it would be downstream farms (farmers) that would benefit from the removal of alien vegetation on farms that are situated upstream. For them this apparently would create a "free-rider" problem, without actually having used these terms in the inverviews, and as rational choice theory indicates, the reasonable option in such cases would be for agents not to cooperate in what they know the socially desirable option would be, but rather to choose the individually desirable option. This is a point regarding the ethical dimensions of climate change that Stephen Gardiner (2006 and 2011) also picks up on in his thesis that climate change creates a perfect moral storm.

Figure 2.17: A river after clearing the alien, invasive vegetation

Farmers were asked to rate the effectiveness of specific measures (set by official structures) pertaining to their farms (Table 2.4):

Table 2.4: Rates of effectiveness of adaptation measures set by official structures

	Highly effective	Effective	Ineffective	Highly Ineffective	Not applicable
4.1 Replace chemical fertilisers with compost, humus, worms, natural minerals.	35%	50%	10%		5%
4.2 Store surplus water (e.g. earth dams, rain tanks on buildings).	45%	35%	20%		
4.3 Re-direct water run-off (to canals, ponds) and recycle water (grey water from houses, factories, etc.).	40%	30%	30%		
4.4 Remove invasive alien plants and other organisms and restore natural habitat.	45%	40%	5%		10%
4.5 Replace old diesel engines.	20%	25%	10%	10%	35%
4.6 Change to renewable energy (wind power, solar power).	5%	50%	20%	25%	
4.6 Change to renewable energy (wind power, solar power).	5%	40%	55%		

2.18 Official structures of support

Farmers were asked to indicate whether or not they think official structures can make a difference with regard to the problems experienced as a result of climate change. 100% of the farmers indicated that the Department of Agriculture and the Department of Water Affairs could make a difference. Of the 20 farmers interviewed:

- 90% of the farmers indicated that the District Municipality could make a difference;
- 90% of the farmers indicated that the South African Weather Bureau can make a difference;
- 80% of the farmers indicated that CapeNature could make a difference;
- 70% of the farmers indicated that the Department of Environmental Management and Development Planning of Western Cape Province could make a difference;
- 45% of the farmers indicated that a Water Management Association could make a difference; and
- 30% of the farmers indicated that a Farmers' Association could make a difference.

Farmers were also asked to indicate the possible changes (Table 2.5) they would like to see with regard to the following role-players (official structures):

Table 2.5: Possible changes recommended by farmers with regard to current official structures

Department of Agriculture:
Goal-orientated research and the practical usage thereof, is a necessity and needs to be addressed. Better communication and feedback on improving agricultural methods and adapting to climate change. In particular, irrigation and the way forward, in the Garden Route area, was singled out as a in serious of attention. Assistance from the Department of Agriculture that can result in a sustainable water usage area was also highlighted. The Department of Agriculture should be more sympathetic to the needs of food producers in the time of a changing climate.
Department of Water Affairs:
Better communication and feedback on applications related to the increase of water storage on farms (dams), and raising dam walls. Each river system should be analysed according to individual characteristics, as well as the need for effective and urgent water management in the Garden Route area. Floodwater management needs serious attention, because 80% of the run-off flows into the sea. Farmers who act in a sustainable way, with regard to water usage, should receive a subsidy.

Department of Environmental Affairs and Developing Planning:
Better communication and feedback on applications related to the increase of water storage on farms (dams). The enforcement of legislation on illegal activities.
District Municipality:
Better communication with farmers is needed. The taxing of agricultural land needs attention; it can be used to assist farmers in sustainable farming practices, considering climate change. Water scarcity needs great emphasis, and alternative methods should be introduced to farmers – for example, the avoidance of carbon emissions should become part of daily practice. Assistance is needed with regard to burning on farms.
CapeNature:
Enforcement of legislation and the restriction of illegal activities need attention.
Farmers' Association:
Not all associations are very active (dormant) and young farmers tend to lose interest. The Chairman of Water Associations should have input with regard to the current legislation (Water Act).
Water Management Association:
Should be more pro-active with regard to water management on farms. The distribution of water to downstream farms needs serious attention.
Weather Bureau:
Better (more accurate) weather predictions are needed.

The words "adaptation to climate change" can be defined as adjustments of a system to reduce the vulnerability of natural and human systems to the effects of climate change. Adaption can either occur in anticipation of change, or it can be a response to change. Furthermore, adaptive capacity and vulnerability are important concepts for understanding adaptation. Adaptive capacity is the ability or potential of a system to respond successfully to climate variability and change, and vulnerability can be seen as the context in which adaptation takes place (Gbetibouo, 2009).

2.19 Conclusion

In this chapter I discussed farmers' perceptions and experiences in relation to temperature change, rainfall patterns and extreme events in the Garden Route. This information was important in determining how farmers have adapted or will adapt in future in response to climate change. For example, although 70 per cent of the farmers indicated that they experienced a slow, overall increase in temperature in the past, only 50 per cent indicated that this trend of a general increase would continue in the future, as opposed to the other 45 per cent of the farmers who indicated that they believe temperatures would follow a trend of both warmer and cooler periods, and 15 per cent of the farmers who indicated that they had no comment with regard to the prediction of future temperatures. Therefore, I deduce that although farmers are well aware of climatic changes, not all of them take steps to adjust their farming activities because not all of them believe that climate change can really occur.

Table 2.5 represents percentages of famers who implemented certain adaptation methods together with percentages of farmers who consider applying certain methods, and those who have not applied certain actions for various reasons. One can argue that a utilitarian agricultural ethic gave rise to the concept of production agriculture, as it is evident that large percentages of farmers have implemented adaptation methods, such as changing crop varieties and the installation of automated irrigation systems in order to produce the same amount or more, despite the effects of climate change.

In addition, consumers now want to know which technologies farmers are, or are not using, i.e. consumers are showing a greater interest in the methods of production that generate their food. This healthy questioning introduces a new element in the equation of food production and marketing (Chrispeels, 2003). Farmers were asked if they had considered the option of conservation farming (or currently practise conservation farming), as well as listing the constraints relating to conservation farming. Forty-five per cent of the farmers indicated that they currently practise conservation farming and that some of them are still in the process of changing to this particular farming method.

Although *some* adaptation methods can be perceived as positive such as conservation farming, the same cannot be said about other adaptation methods and current practises implemented by farmers. Agriculture requires not only the replacement of natural ecosystems with crop fields (with accompanying loss of biodiversity and massive carbon dioxide release) but results in groundwater pollution, soil erosion, aquifer depletion, soil degradation, pesticide pollution, and other environmental stresses in the Garden Route. The predicted impacts of climate change raise questions of rights and corresponding duties and place emphasis on the adaptation methods farmers apply or fail to apply.

Another major dilemma in the Garden Route is the infestation of alien invasive vegetation. Alien vegetation, which infests large tracts of otherwise undisturbed mountains and flats, has become a major threat to fynbos vegetation and plant diversity. Furthermore, riverflow is affected as these plants take up large volumes of water. The removal of alien vegetation should result in changing the volume of run-off in rivers, thereby creating more irrigation potential for farmers.

From the results obtained in Table 2.5 it is evident that not all the farmers have adapted to climatic changes by removing all alien invasive vegetation on their properties. Legislation has been laid down to promote the control of alien vegetation, but it is not always implemented by the farmers. One reason for this is that farmers do not have the economic incentive to do so. Some farmers only remove alien vegetation for aesthetic purposes, or as deemed and required by a landlord. Farmers also stated that it could be a difficult task to remove these trees, due to the topography and accessibility of certain areas.

Farmers indicated that it remains an ethical challenge for each farmer to remove alien vegetation on his own property, because ultimately, the downstream farms (farmers) would benefit from the removal of alien vegetation on farms that are situated upstream. One can argue that farmers who do remove alien vegetation see it as their obligation or duty and therefore follow a deontological approach in the matter. One can also argue that the character or virtue of a farmer is reflected in his or her willingness to remove alien vegetation from the farm. In this regard, one can refer to the classical statement by Aldo Leopold (1970), “A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise”. In terms of this statement, the failure to actively adapt to climate change, or to actively take measures that can contribute to adaptation, can also be seen (in theory) as a moral failure. However, such a strong judgement was actually not made by farmers who participated in the study, the reasons for which were not probed in this study, and is left for another investigation.

In conclusion to this chapter it is therefore important to note that the availability of water for agricultural purposes in the Garden Route remains a problem in relation to adaptation and perception of climate change and what the future might hold in this regards if farmers do to not adapt accordingly, as will be discussed in more detail in Chapter 5.

CHAPTER 3: **CLIMATIC DATA VERSUS RESULTS OF FARMERS' PERCEPTIONS**

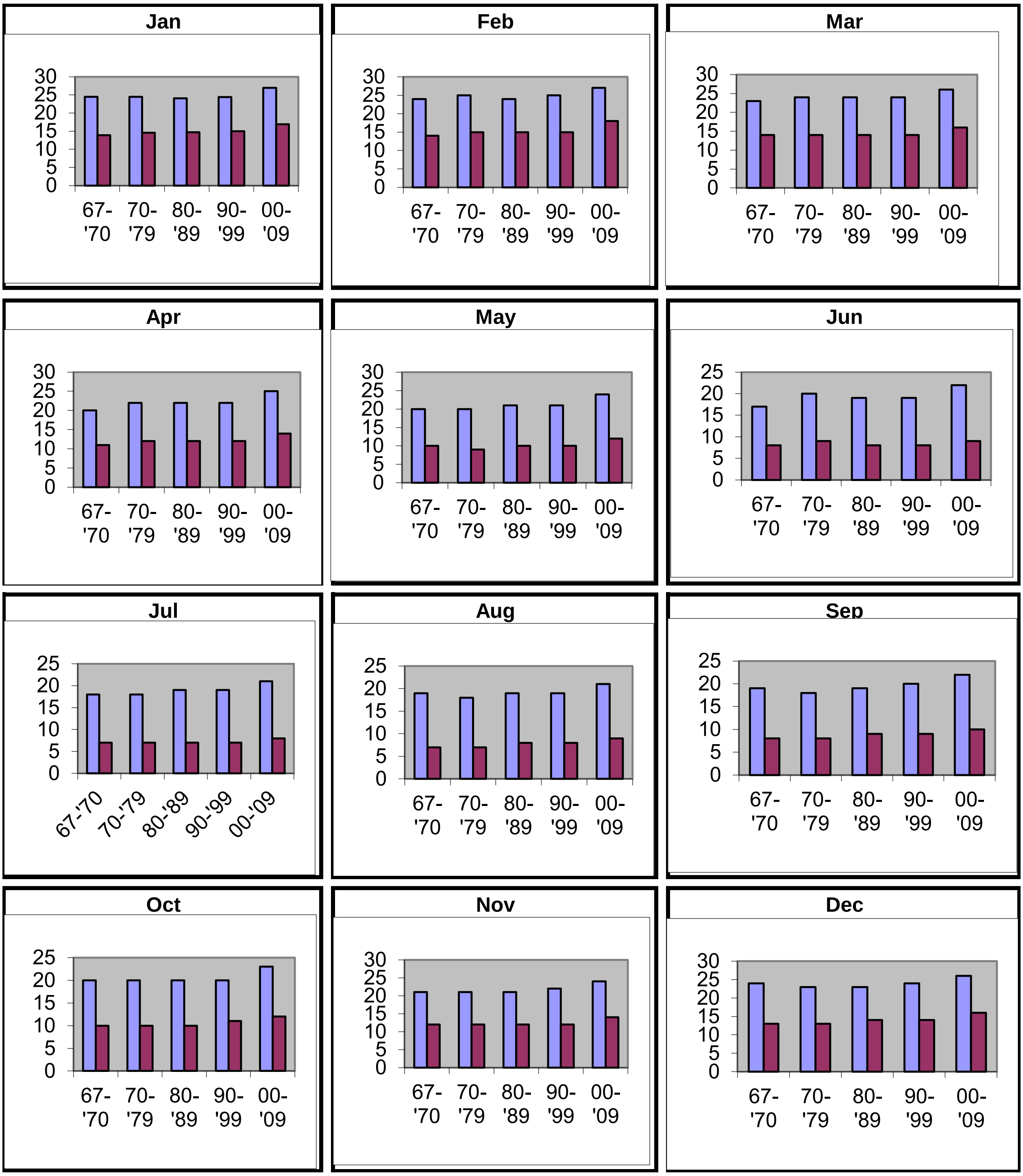
This chapter represents the results of the survey of farmers' perceptions on temperatures, combined with climatic data obtained from the CSIR. The farmers that were interviewed did not receive the actual figures of minimum and maximum temperatures; their answers were based on their perceptions and experiences of minimum and maximum temperatures over the years of their own experience. The method of presenting the results entails providing the actual minimum and maximum temperatures as well as rainfall data as obtained from the CSIR in graphs and tables. The perception trends of minimum and maximum temperatures and rainfall as experienced by the famers are also presented in graphs and tables. A discussion of these results is provided in Chapter 5.

3.1 Minimum and maximum temperatures *versus* farmers' perceptions

Table 3.1 represents the average minimum and maximum temperatures recorded at the Outeniqua Weather Station during the period of 1967 to 2008; Figure 3.1 represents the *trend* of minimum and maximum temperatures for the same period of time.

Table 3.1: Minimum and maximum temperatures recorded at the Outeniqua Weather Station from 1967–2008

Average temperature: 1967–2008: Tx = Maximum temperature; Tn = Minimum temperature (Data: CSIR)																								
	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Tx	Tn	Tx	Tn	Tx	Tn	Tx	Tn	Tx	Tn	Tx	Tn	Tx	Tn	Tx	Tn	Tx	Tn	Tx	Tn	Tx	Tn	Tx	Tn
67-'69	24	14	24	14	23	14	20	11	20	10	17	8	18	7	19	7	19	8	20	10	21	12	24	13
70-'79	24	15	25	15	24	14	22	12	20	9	20	9	18	7	18	7	18	8	20	10	21	12	23	13
80-'89	24	15	24	15	24	14	22	12	21	10	19	8	19	7	19	8	19	9	20	10	21	12	23	14
90-'99	24	15	25	15	24	14	22	12	21	10	19	8	19	7	19	8	20	9	20	11	22	12	24	14
00-'08	27	17	27	18	26	16	25	14	24	12	22	9	21	8	21	9	22	10	23	12	24	14	26	16
% Change in average temperature: 1967–2008																								
	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Tx	Tn	Tx	Tn	Tx	Tn	Tx	Tn	Tx	Tn	Tx	Tn	Tx	Tn	Tx	Tn	Tx	Tn	Tx	Tn	Tx	Tn	Tx	Tn
67-'69	0	1	2	3	4	5	7	8	9	10	11	12	13	14	16	17	18	19	20	21	22	23	24	25
70-'79	0	7	4	7	4	0	10	9	0	-10	18	13	0	0	-5	0	-5	0	0	0	0	0	-4	0
80-'89	0	0	-4	0	0	0	0	0	5	11	-5	-11	6	0	6	14	6	13	0	0	0	0	0	8
90-'99	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	10	5	0	4	0
00-'08	13	13	8	20	8	14	14	17	14	20	16	13	11	14	11	13	10	11	15	9	9	17	8	14



Data: CSIR

Figure 3.1 Representation of the trend in maximum and minimum temperatures as recorded at the Outeniqua Weather Station from 1967–2008 (Y-axis = °C: X-axis = years)

Both Table 3.1 and Figure 3.1, indicate a trend of *slow* increase in the actual minimum and maximum temperatures for the period of time between 1967 and 2008. Of the 20 farmers interviewed, 35% of the farmers had observed an *increase* in the maximum temperatures over the years as indicated in Figure 3.1.

Figure 3.2 represents the trend of *when* these farmers observed the increase in maximum temperatures.

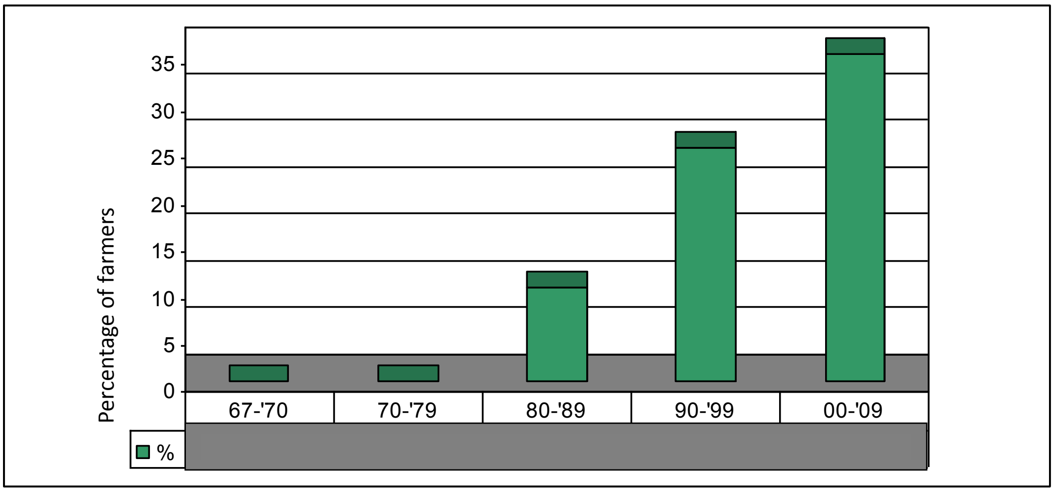


Figure 3.2: Farmers' perceptions trend of an increase in maximum temperatures over the years

Of the 20 farmers interviewed, 90% of the farmers had observed an *increase* in the minimum temperatures over the years. Figure 3.3 represents the trend of *when* these farmers observed the increase in minimum temperatures during their farming experience.

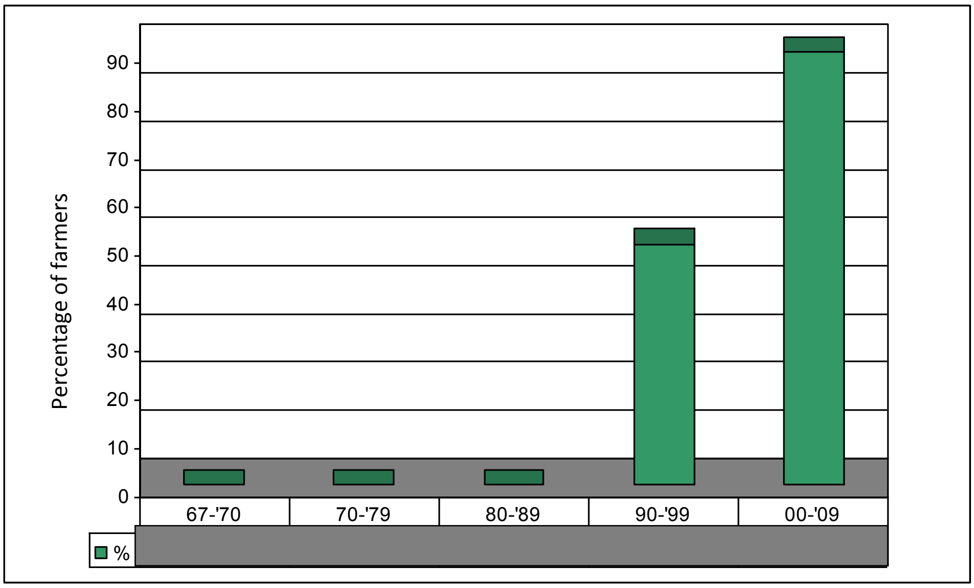


Figure 3.3: Farmers' perceptions trend of an increase[11] in minimum temperatures over the years

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[11] Farmers are focused to observe minimum temperatures because that guides them in relation to their irrigation time and volume.

Figures 3.4 and 3.5 represent the trends of the *actual* increase in temperatures *versus* the trends of *farmers' perceptions*, who observed an increase in temperatures over the period of time between 1967 and 2008.

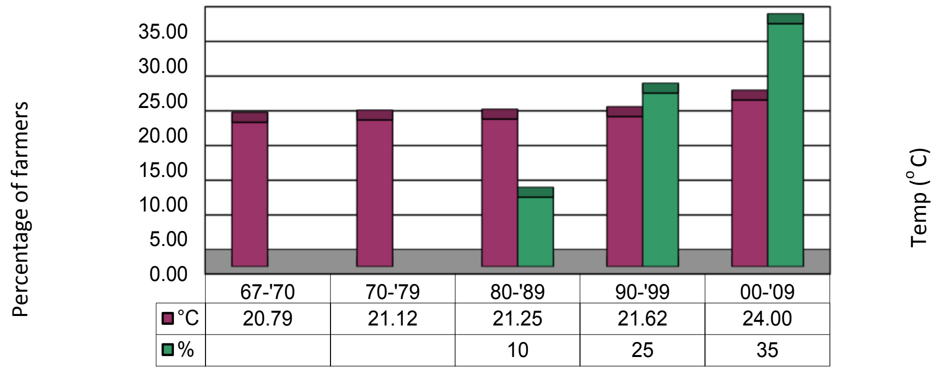

Figure 3.4: Farmers' perceptions trend of maximum temperatures versus the actual maximum temperature trend from 1967–2008

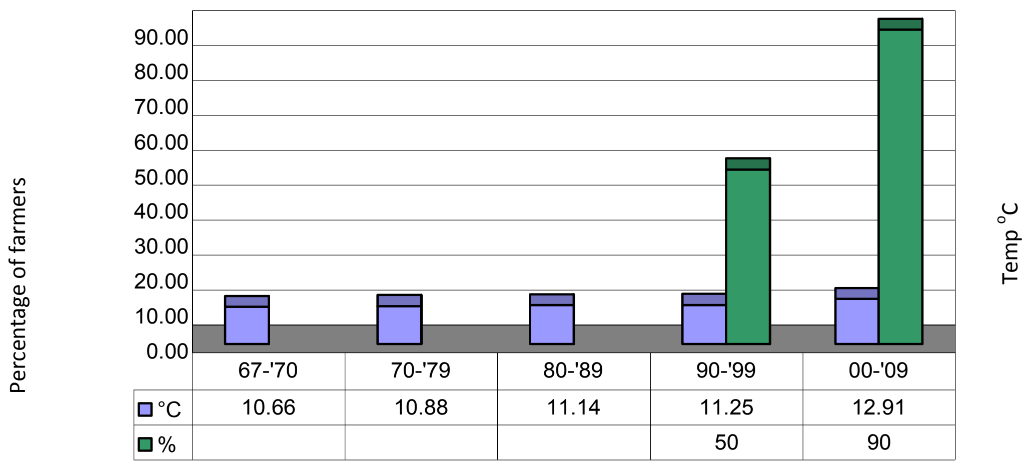

Figure 3.5: Farmers' observations trend of minimum temperatures versus the actual minimum temperature trend from 1967–2008

Of the farmers who observed an increase in temperatures over the years, the majority of these farmers were more aware of the *increase* in *minimum* temperatures. Farmers indicated that a big influencing factor could be the usage of instruments that measure soil temperature.

Figure 3.6 represents the percentage of days in which the extreme *minimum* temperatures were measured, and showed an increase in the minimum temperatures; depicting a definite linear trend. Minimum temperatures have increased significantly.

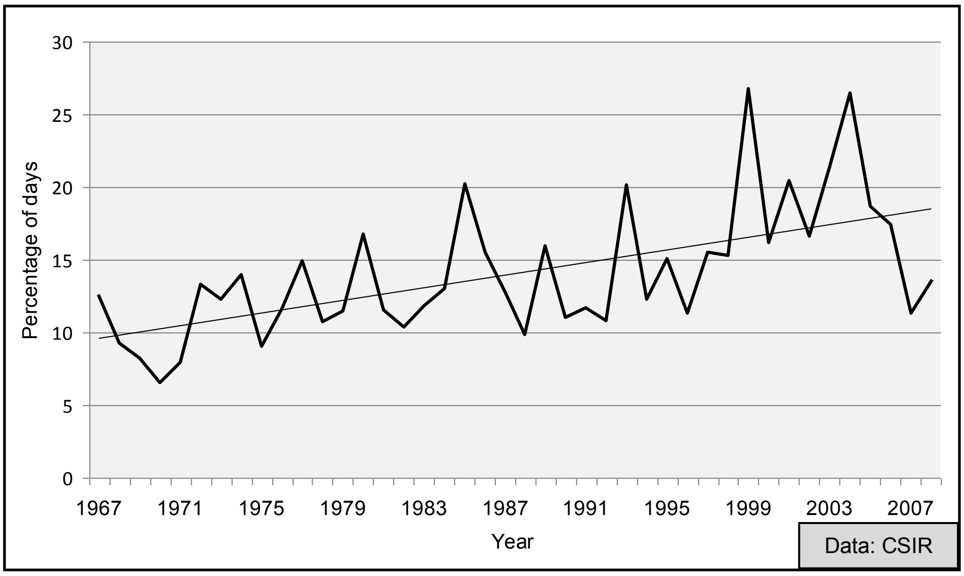

Figure 3.6: Increase in extreme minimum temperatures measured at the Outeniqua Weather Station from 1967–2008

Farmers were asked to indicate if they have experienced an increase in the number of very hot (extreme) days[12]. 50% of the farmers observed an increase in the number of very hot days; while 50% of the farmers did not observe an increase in the number of very hot days. Figure 3.7 represents the percentage of very hot days between the period of 1967 to 2008.

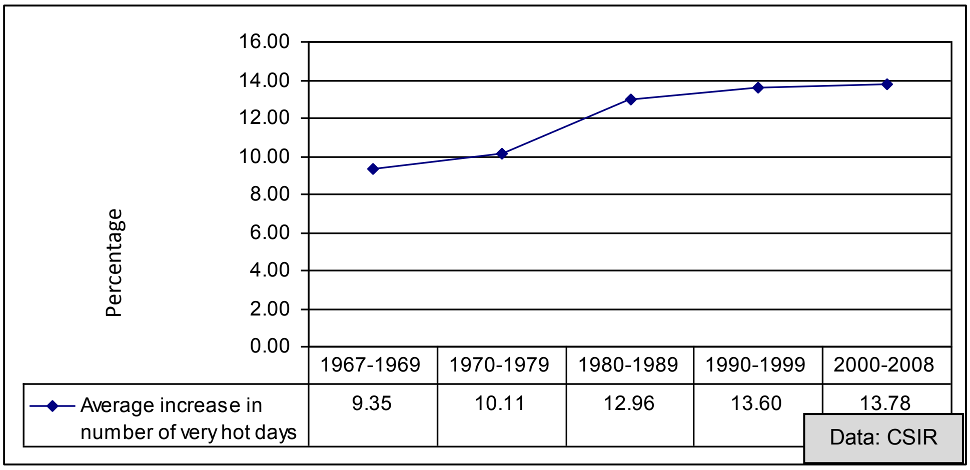

Figure 3.7: Increase in the number of very hot (extreme) days from 1967–2008

There are a host of models developed by various meteorological offices worldwide. The Hadley Centre for Climate Prediction and Research, of the United Kingdom Meteorological Office, developed a model which is used to predict climate changes for the Western Cape region (Erasmus *et al*., 2000). Global Climate Models and associated Regional Climate

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[12] Hot (extreme) days defined as 30 degrees Celsius and above in this context.

Models predict a general increase of 1.5–2 °C in minimum and maximum temperatures for the coastal area during all months over the next 30 years (see Figure 3.8).

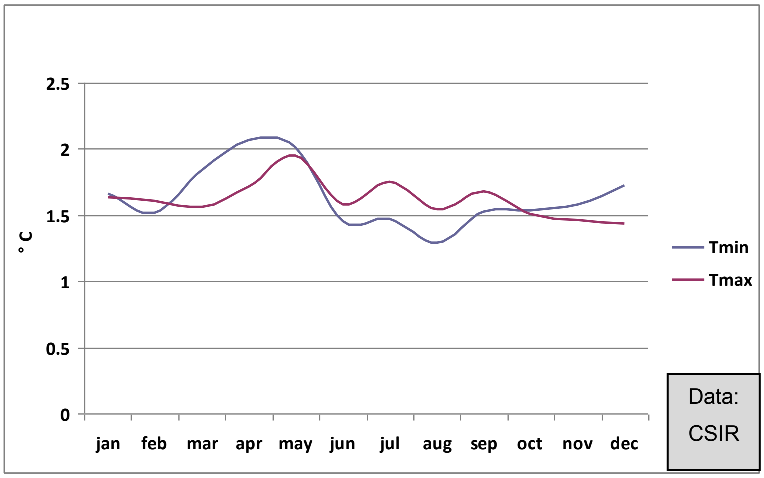

Figure 3.8: Future minimum and maximum anomaly for the George area

Increased minimum and maximum temperatures inevitably mean an increase in potential evaporation, which is likely to have profound effects on irrigated crop production through changes in crop growth rate, crop water demand, soil moisture and irrigation scheduling (Kabat *et al.*, 2002; Schultze, 2003). In total, 65% of the farmers perceived a change in the minimum and maximum temperatures over the years. Agriculture will increasingly need to adopt new, or expand on, current adaptation strategies and alternatives to be able to respond to the challenges posed by global climate change.

3.2 Rainfall *versus* farmers' perceptions

The farmers that were interviewed for this study also did not receive the actual rainfall data obtained from the CSIR; their answers were more based on their perceptions and experiences of rainfall over the years. Figure 13.11 on p66 represents rainfall data (which was analysed for trends in monthly and annual total rainfall, as well as heavy rainfall events), for the various climate stations in the Garden Route region as defined in footnote 1 and portrayed in Figure 1.3 in Chapter 1 p29.

According to *Severe weather compound disaster* (DiMP, 2007), the Garden Route area receives rainfall all year round, governed mainly by two rain-producing systems namely, cold fronts and secondly westerly waves that approach from the west over the Western Cape. The sharp rainfall gradient between the mountains and the ocean contributes to an increase in the mean annual rainfall (MAP) on the highest mountain peaks of the Outeniqua mountains, and a decrease near the coast. Trends differed between lowland and mountain areas (Figure 3.11 and Figure 3.12).

Average Annual Rainfall (as per Station)

	1967-1969	1970-1979	1980-1989	1990-1999	2000-2008
Bergplaats	780	719	814	764	663
Herbertsdale	354	386	476	448	448
Karatara	764	771	766	822	727
Plettenberg Bay	581	686	726	658	614
Sandhoogte	485	542	534	492	463
Outeniqua	685	659	731	793	691

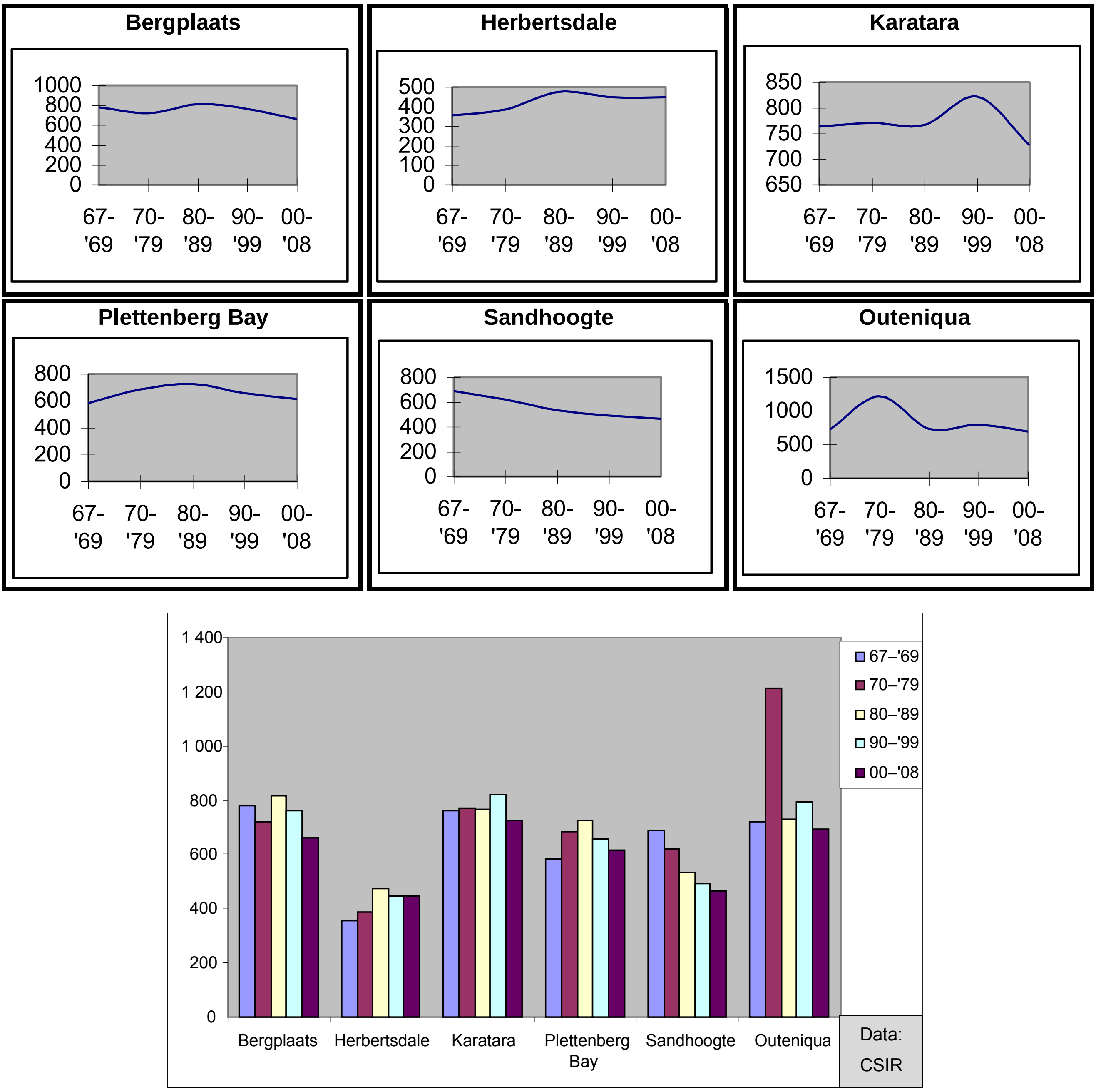

Figure 3.9: Average rainfall data recorded at various weather stations in the Garden Route area

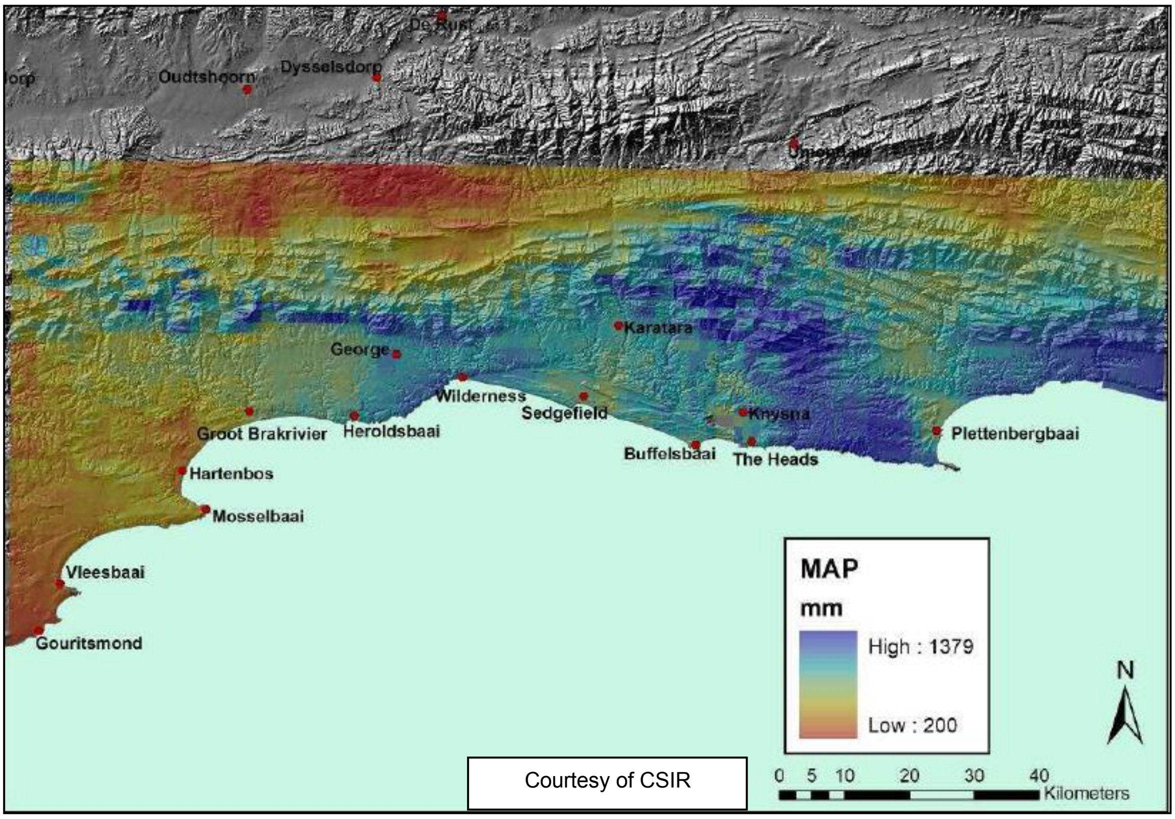

Figure 3.10: Rainfall trends in lowland and Outeniqua mountain areas

The following observations (Figures 3.13 and 3.14) were recorded at the Outeniqua Weather Station. The observed rainfall trend (Figure 3.13), and monthly trend (Figure 3.14), highlight a more pronounced decrease in rainfall during the winter months, and significant increases in rainfall during early summer and the period between March and April.

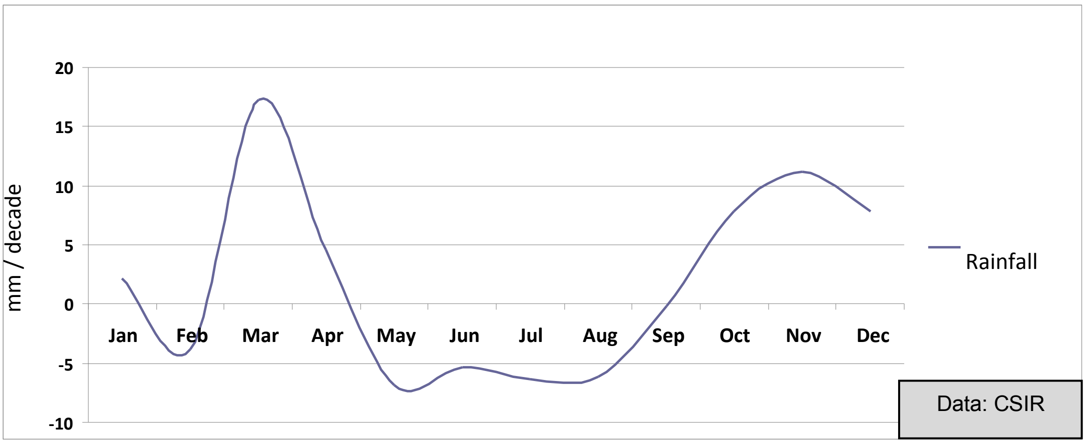

Figure 3.11: Observed rainfall trend at the Outeniqua Weather Station from 1970–2008

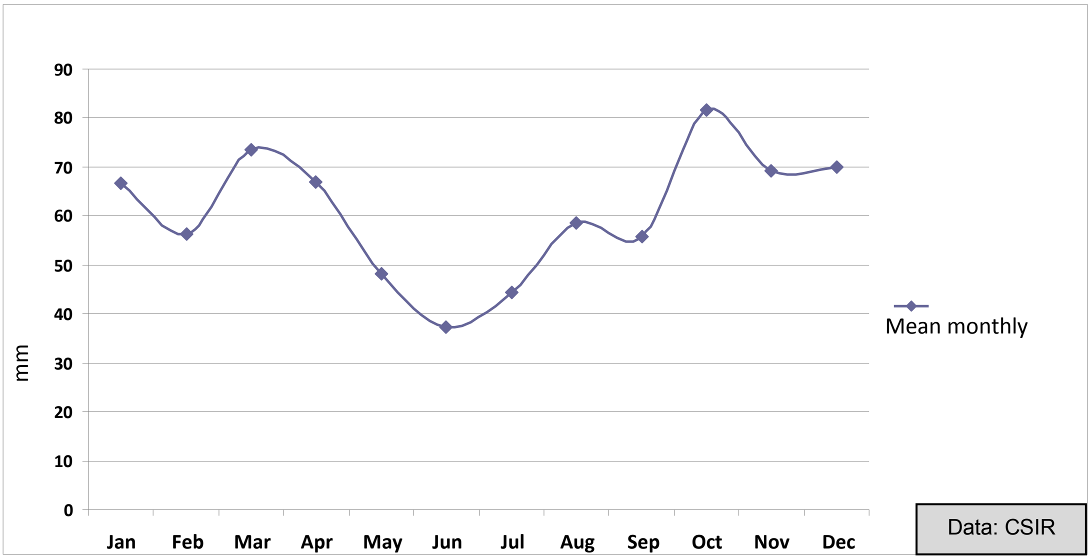

Figure 3.12: Observed mean monthly rainfall trend at the Outeniqua Weather Station from 1970–2008

Figure 3.15 represents the total annual rainfall observed at the Outeniqua Weather Station. Of the 20 farmers interviewed, 75% perceived a *decrease* in rainfall over the years; 10% of the farmers perceived an *increase* in rainfall over the years; 15% of the farmers had *not* perceived a change in rainfall over the years. The perception of the decrease in rainfall might be influenced by the fact that the rainfall pattern in the Garden Route area has changed. Rainfall has become more erratic and less frequent. Most farmers formulated the change in rainfall as an increasing variability.

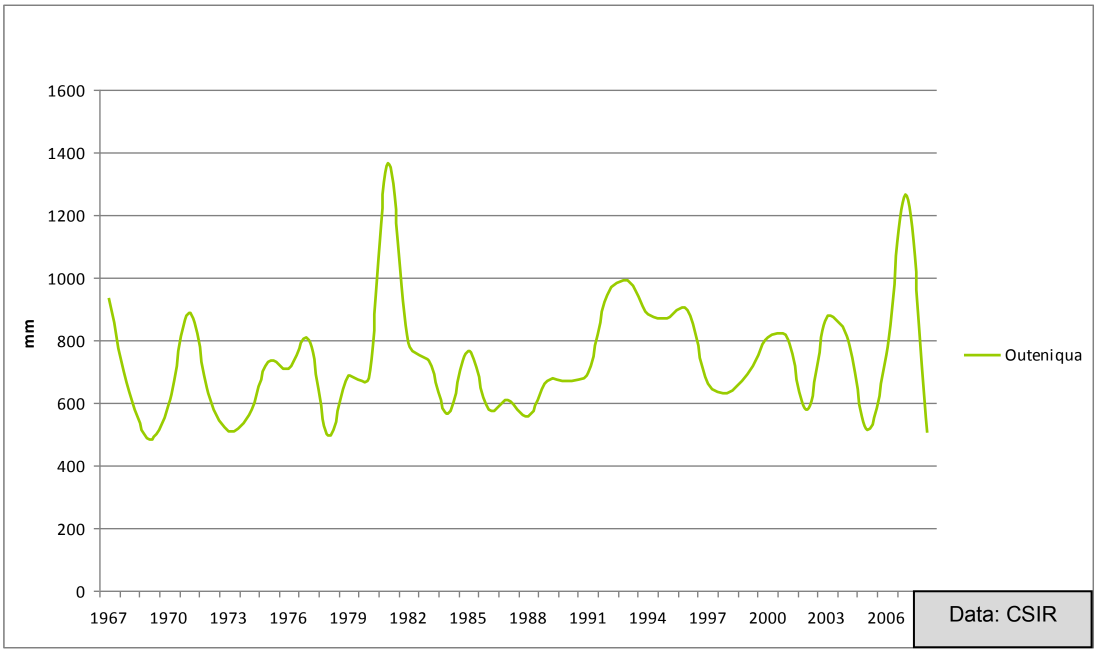

Figure 3.13: Observed total annual rainfall at the Outeniqua Weather Station from 1967–2008

Figure 3.16 represents an observed increasing linear trend in extreme rainfall events[13] over the period between 1967 and 2008.

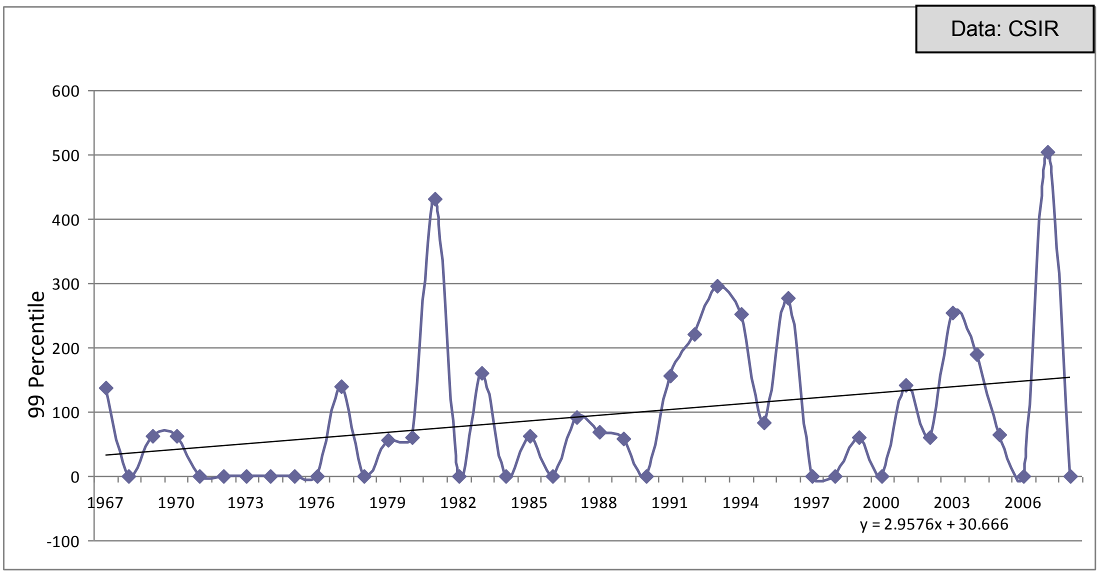

Figure 3.14: Observed extreme rainfall events at the Outeniqua Weather Station from 1970–2008

From the results obtained and compared with the views of the farmers in this chapter the evidence for a change in global climate is accumulating. The majority of these farmers were more aware of the increase in minimum temperatures, therefore that their perception and experience correspond with the actual figures as obtained from the CSIR. A possible reason for this is that farmers have over the last ten to twenty years become aware of the importance of minimum temperatures in relation to their agricultural practices and crops. Agricultural methods will increasingly need to adopt new, or expand on, current adaptation strategies and alternatives to be able to respond to the challenges posed by global climate change as discussed in more detail in Chapter 5 and Chapter 6 of this study.

[13] Extreme rainfall events are defined as floods in this context.

CHAPTER 4: **RESULTS OF THE HECKMAN PROBIT ADAPTATION MODEL**

This chapter reflects the results of the Heckman Probit Adaptation Model. The Model determines the likelihood of farmers perceiving climate change, as well as the likelihood of farmers actually adapting to these changes. The dependent variable for the *selection* equation is binary, indicating whether or not a farmer perceives climate change. The dependent variable for the *outcome* equation is also binary, indicating whether or not a farmer responded to the perceived changes by adapting his or her farming practices. The likelihood function for the Heckman Probit Adaptation Model was significant where $P<0.005$. In this chapter it is shown that a large percentage of the farmers that were interviewed did observe changes in climate; however, they did not always take remedial action (Gbetibouo, 2009).

In the first two sections it is determined whether or not farmers perceived climate change (according to the list of variables discussed below). In these two sections univariate comparisons are made, and in the third section it is determined whether or not farmers adapted to the change according to the list of independent predictor variables used in the first two sections. These questions were formulated together with Professor Martin Kidd of the Centre for Statistical Consultation (CSC) of Stellenbosch University who calculated the results of the Heckman Probit Adaptation Model (Refer to Annexure C). The methodology entailed the following:

Univariate analyses were conducted to determine which factors had significant effects on farmers experiencing climate change and adapting to climate change, using cross tabulation and the Chi-square test for categorical variables, and one-way ANOVA for ordinal/continuous variables. In addition to the ANOVAs, non-parametric Mann-Whitney U tests were also conducted[14].

For multivariate analysis, the Heckman Probit Model was used to determine the combined effects of factors on experiencing and adapting to climate change with 20 famers. The sample test was small due to financial constraints.

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[14] Tests used by Professor Martin Kidd, Centre for Statistical Consultation, Univerity of Stellenbosch.

The first section of this study determined whether or not farmers perceived climate change (according to the list of variables discussed below), and the second section of this study determined whether or not farmers adapted to the change according to the list of independent predictor variables discussed in the second section of this chapter. Sections 1 and 2 of Chapter 4 are devoted to univariate comparisons and in Section 3 these variables are combined in the Heckman Probit analysis.

4.1 First section: Univariate results for perception of climate change

4.1.1 Choice of variables and questions probed:

Based on the information received from farmers on their perceptions and adaptation choices to climate change, six independent variables were included in the Model to determine experience (perception) of climate change, namely:

1. Water Management Association (WMA) – membership (binary)
2. Conservation farming (binary)
3. Organic farming (binary)
4. Area irrigated (continuous)
5. Years of farming experience (continuous)
6. Education (categorical)

Around each one of these variables a question was formulated that was used to probe to what extent and how that variable corresponded with the perception of climate change or not. The results of the respective probes related to each question are given below.

4.1.2 Water Management Association

4.1.2.1 Question probed

Is there a relationship between experience (perception) of farmers of climate change and their membership of a Water Management Association?

4.1.2.2 Results

Two definite groups were distinguished: (1) Farmers who do not belong to Water Management Associations, and (2) farmers who belong to Water Management Associations.

First group (1): 60% of the farmers who did not belong to a Water Management Association, reported that they experienced climate change; the other 40% of the farmers who did not belong to a Water Management Association, did not report that they experienced climate change.

Second group (2): 50% of the farmers who do belong to Water Management Associations, reported that they experienced climate change; the other 50% of the farmers who do belong to Water Management Associations, did not report that they experiencee climate change.

In order to make a significant conclusion P<0.005, where in this case P=0.5000. Therefore, membership to a Water Management Association *did not* significantly influence the perception of climate change.

Table 4.1: Water Management Association and perception of climate change

	Chi-square(df=1)=0.20, p=.65281 Fisher exact, one-tailed p=.50000		
Question 1.3	**Farmer experienced climate change "yes"**	**Farmer experienced climate change "no"**	**Row totals**
No	6	4	10
Row %	60.00%	40.00%	
Yes	5	5	10
Row %	50.00%	50.00%	
Totals	11	9	20

4.1.3 Conservation farming

4.1.3.1 Question probed

Is there a relationship between experience (perception) of farmers of climate change and who practise conservation farming?

4.1.3.2 Results

Two definite groups were distinguished: (1) Farmers who do not practise conservation farming, and (2) farmers who practise conservation farming.

First group (1): 100% of the farmers, who do not practise conservation farming, experienced climate change.

Second group (2): 25% of the farmers who do practise conservation farming, experienced climate change; 75% of the farmers who do practise conservation farming, did not experience climate change.

A significant difference (p<0.001) was found between the two groups. Farmers who do not practise conservation farming, experience climate change. On the other hand, farmers that do practise conservation farming do not experience climate change as much as the farmers who don't.

Table 4.2: Conservation farming and perception of climate change

	Chi-square(df=1)=14.03, p=.00018 Fisher exact, one-tailed p=.00131		
Question 8.3.3	**Farmer experienced climate change "yes"**	**Farmer experienced climate change "no"**	**Row totals**
No	8	0	8
Row %	100.00%	00.00%	
Yes	3	9	12
Row %	25.00%	75.00%	
Totals	11	9	20

4.1.4 Organic farming

4.1.4.1 Question probed

Is there a relationship between experience (perception) of farmers of climate change and who practise organic farming?

4.1.4.2 Results

Two definite groups were distinguished: (1) Farmers who do not practise organic farming, and (2) farmers who practise organic farming.

First group (1): 25% of the farmers who do not practise organic farming, experience climate change; 75% of the farmers who do not practise organic farming, did not experience climate change.

Second group (2): 100% of the farmers who practise organic farming, experience climate change.

A significant difference ($p<0.001$) was found between the two groups. Farmers who practise organic farming, experience climate change. On the other hand, farmers that do not practise organic farming do not experience climate change that easily.

Table 4.3: Organic farming and perception of climate change

	Chi-square(df=1)=14.03, p=.00018 Fisher exact, one-tailed p=.00131		
Question 1.3	**Farmer experienced climate change "yes"**	**Farmer experienced climate change "no"**	**Row totals**
No	3	9	12
Row %	25.00%	75.00%	
Yes	8	0	8
Row %	100.00%	00.00%	
Totals	11	9	20

4.1.5 Area irrigated

4.1.5.1 Question probed

Is there a relationship between the experience (perception) of farmers of climate change who irrigate larger areas and those farmers who irrigate smaller areas of land?

4.1.5.2 Results

Area is a continuous measurement and averages (ha) were determined. The only groups determined were farmers who experienced climate change and those who did not experience climate change. In order to make a significant conclusion $P<0.005$, where in this case $P=0.21$.

A possible trend is shown in Figure 4.1 below, between area 150 ha and 300 ha.

Farmers irrigating smaller areas might experience climate change more than those farmers irrigating larger areas, but the random test was too small to make a significant conclusion.

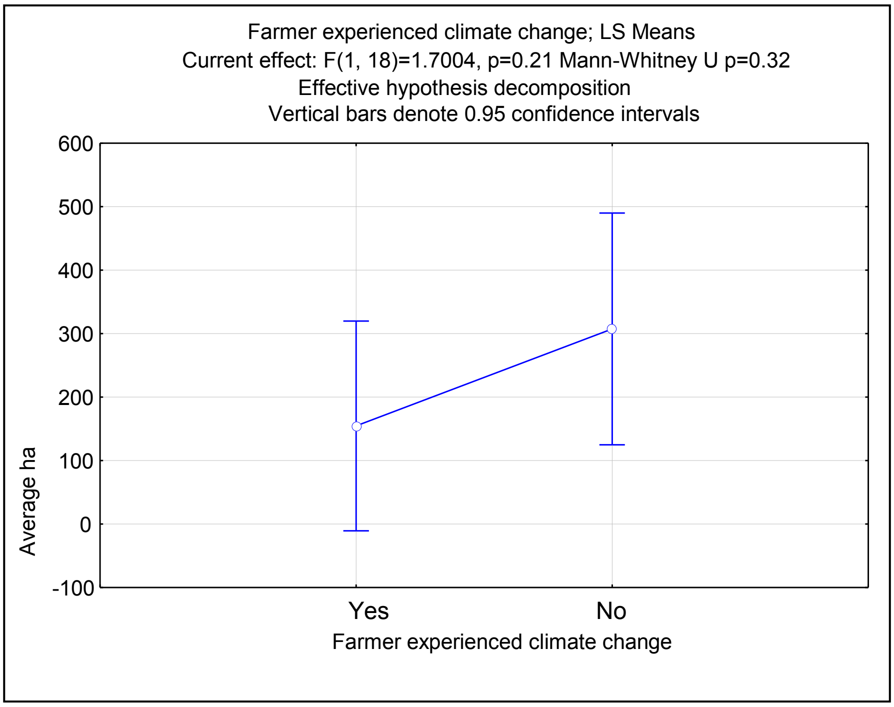

Figure 4.1: Farmers' experience of climate change where the area irrigated acts as a variable

Table 4.4: Farmers' experience of climate change where the area irrigated acts as a variable

		Descriptive statistics (subset in Heckman.stw)					
Effect	**Level of factor**	**No.**	**Mean**	**Std. Dev**	**Std. Err**	**-95.00%**	**+95.00 %**
Total		20	223.300	265.444	59.355	99.0680	347.532
Farmer experienced climate change	Yes	11	154.545	173.816	52.407	37.7737	271.317
Farmer experienced climate change	No	9	307.333	339.315	113.105	46.5120	568.154

4.1.6 Years of farming experience

4.1.6.1 Question probed

Is there a relationship between experience (perception) of farmers of climate change who have more years of farming experience and those farmers with less years of farming experience?

4.1.6.2 Results

Two definite groups were distinguished: (1) Farmers with more years of experience, and (2) farmers with less years of experience. In order to make a significant conclusion $P<0.005$, where in this case P=0.15. A possible trend is shown in Figure 4.2 below, between 25 years of farming experience and 32 years of farming experience. Farmers with more years of farming experience are more likely to experience climate change, but the random test was too small to make a significant conclusion.

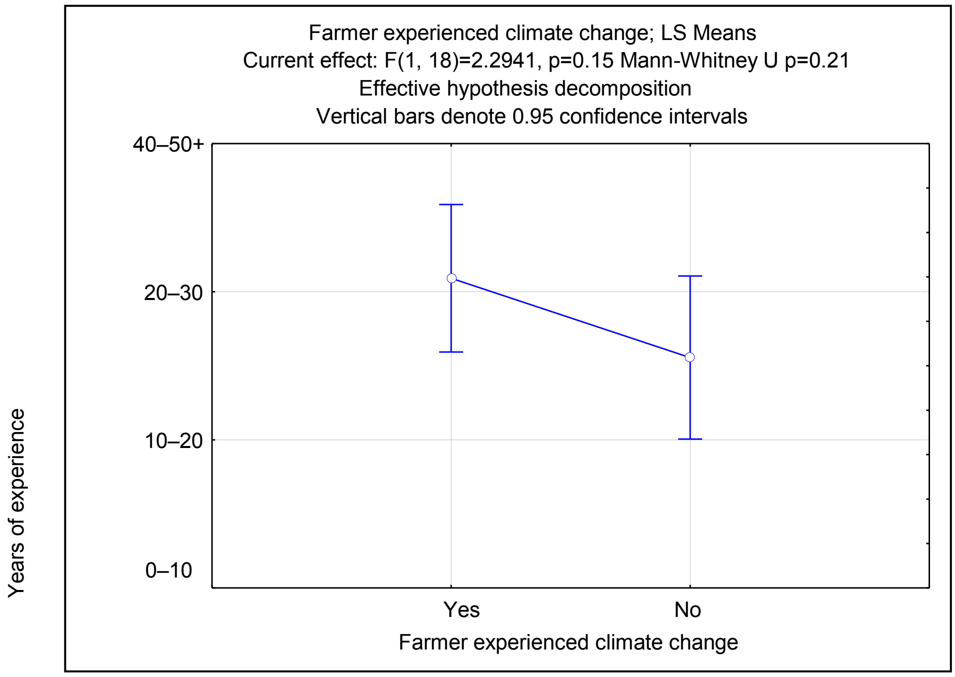

Figure 4.2: Farmers' experience of climate change where years of experience in farming acts as a variable

Table 4.5: Farmers' experience of climate change where years of experience in farming acts as a variable

			Descriptive statistics (subset in Heckman.stw)				
Effect	**Level of factor**	**No.**	**Mean**	**Std. Dev**	**Std. Err**	**-95.00%**	**+95.00%**
Total		20	2.850000	0.812728	0.181731	2.469632	3.230368
Farmer experienced climate change	Yes	11	3.090909	0.700649	0.211254	2.620207	3.561612
Farmer experienced climate change	No	9	2.555556	0.881917	0.293972	1.877654	3.233457

4.1.7 Education

4.1.7.1 Question probed

Is there a relationship between experience (perception) of farmers who have further education and those farmers who have not studied further?

4.1.7.2 Results

Two definite groups were distinguished: (1) Farmers who studied further, and (2) farmers who did not study further. In order to make a significant conclusion P<0.005, where in this case P=0.58. The larger P value indicates no significant trend.

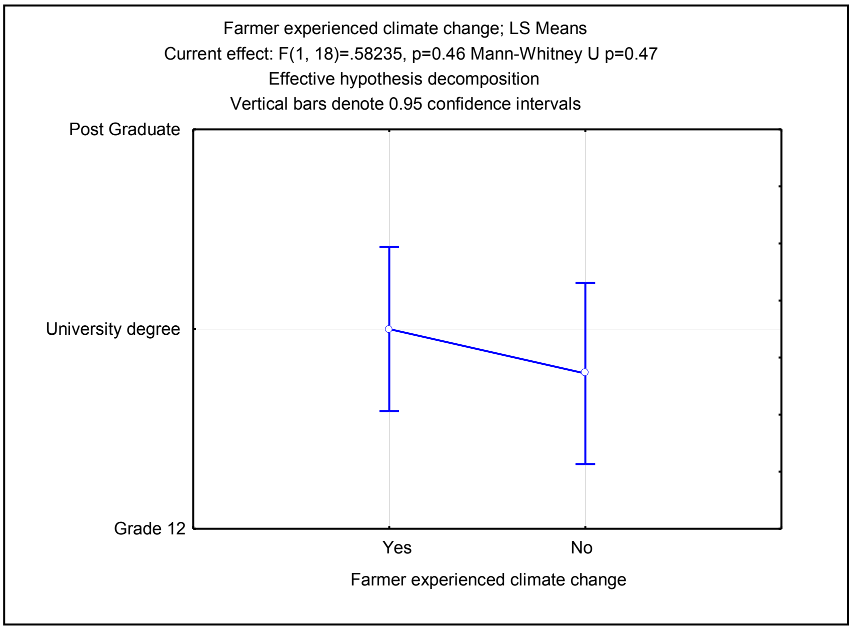

Figure 4.3: Farmers' experience of climate change where further education acts as a variable

Table 4.6: Farmers' experience of climate change where further education acts as a variable

			Descriptive statistics (subset in Heckman.stw)				
Effect	**Level of factor**	**No.**	**Mean**	**Std. Dev**	**Std. Err**	**-95.00%**	**+95.00%**
Total		20	2.900000	0.640723	0.143270	2.600132	3.199868
Farmer experienced climate change	Yes	8	3.000000	0.534522	0.188982	2.553128	3.446872
Farmer experienced climate change	No	12	2.833333	0.717741	0.207194	1.377303	3.289364

4.2 Second section: Univariate results for adaptation to climate change

This section presents the results of the Heckman Probit adaptation Model in which adaptations to climate change were measured according to results from the previous section. The independent predictor variables tested were:

1. Water Management Association
2. Area irrigated
3. Years of farming experience
4. Education
5. Access to credit

4.2.1 Water Management Association

4.2.1.1 Question probed

Is there a relationship between farmers belonging to a Water Management Association, and adaptation to climate change?

4.2.1.2 Results

Two definite groups were distinguished: (1) Farmers who do not belong to Water Management Associations, and (2) farmers who belong to Water Management Associations.

First group (1): 40% of the farmers who did not belong to a Water Management Association, adapted to climate change; the other 60% of the farmers who did not belong to a Water Management Association, did not adapt to climate change.

Second group (2): 40% of the farmers who do belong to Water Management Associations, adapted to climate change; the other 60% of the farmers who do belong to Water Management Associations, did not adapt to climate change.

In order to make a significant conclusion $P<0.005$, where in this case $P=0.67504$. Therefore, membership of a Water Management Association *did not* significantly influence adaptation to climate change.

Table 4.7: Water Management Association and adaptation

	Chi-square(df=1)=0.00, p=1.0000 Fisher exact, one-tailed p=0.67504		
Question 1.3	**Farmer adapted to climate change "yes"**	**Farmer adapted to climate change "no"**	**Row totals**
No	4	6	10
Row %	40.00%	60.00%	
Yes	4	6	10
Row %	40.00%	60.00%	
Totals	8	12	20

4.2.2 Area irrigated

4.2.2.1 Question probed

Is there a relationship between farmers who irrigate larger areas, and adapt to climate change; to those farmers who irrigate smaller areas and their adaptation to climate change?

4.2.2.2 Results

Area is a continuous measurement and averages (ha) were determined. The groups determined were farmers who adapted to climate change and those who did not adapt to climate change.

In order to make a significant conclusion P<0.005, where in this case P=0.48. The larger P value indicated no trend and the random test was too small to make a significant conclusion.

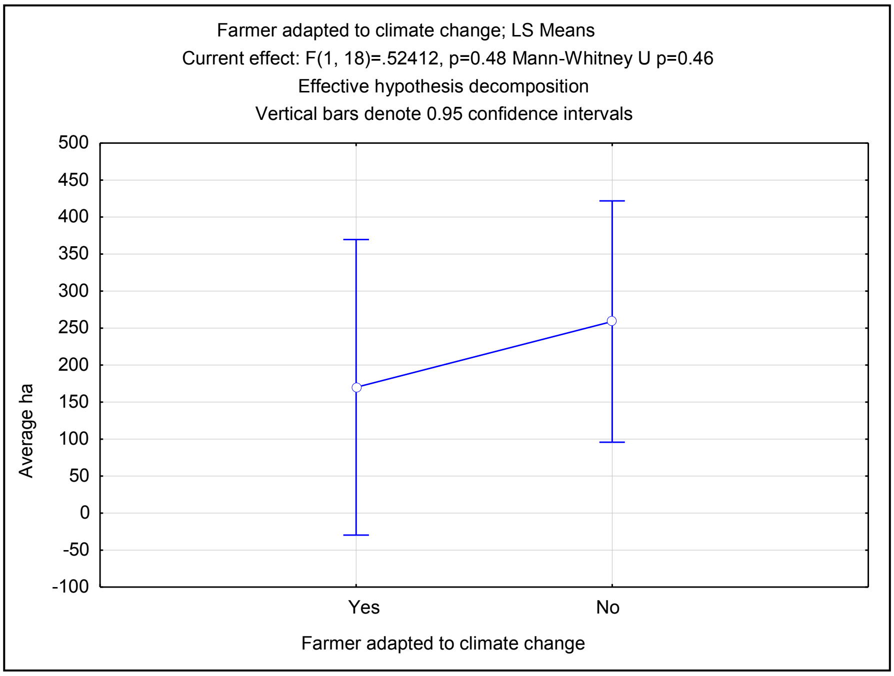

Figure 4.4: Farmers' adaptation to climate change where the area irrigated acts as a variable

Table 4.8: Farmers' adaptation to climate change where the area irrigated acts as a variable

			Descriptive statistics (subset in Heckman.stw)				
Effect	**Level of factor**	**No.**	**Mean**	**Std. Dev**	**Std. Err**	**-95.00%**	**+95.00%**
Total		20	223.3000	265.4448	59.355	99.0680	347.532
Farmer adapted to climate change	Yes	8	170.0000	188.3007	66.574	12.57670	327.423
Farmer adapted to climate change	No	12	258.8333	309.3512	89.301	62.28097	455.385

4.2.3 Years of farming experience

4.2.3.1 Question probed

Is there a relationship between farmers who have more years of farming experience and adaptation to climate change; to those farmers with less years of farming experience, and adaptation to climate change?

4.2.3.2 Results

Two definite groups were distinguished: (1) Farmers with more years of experience, and (2) farmers with less years of experience. In order to make a significant conclusion P<0.005, where in this case P=0.52. The larger P value indicated no trend and the random test was too small to make a significant conclusion.

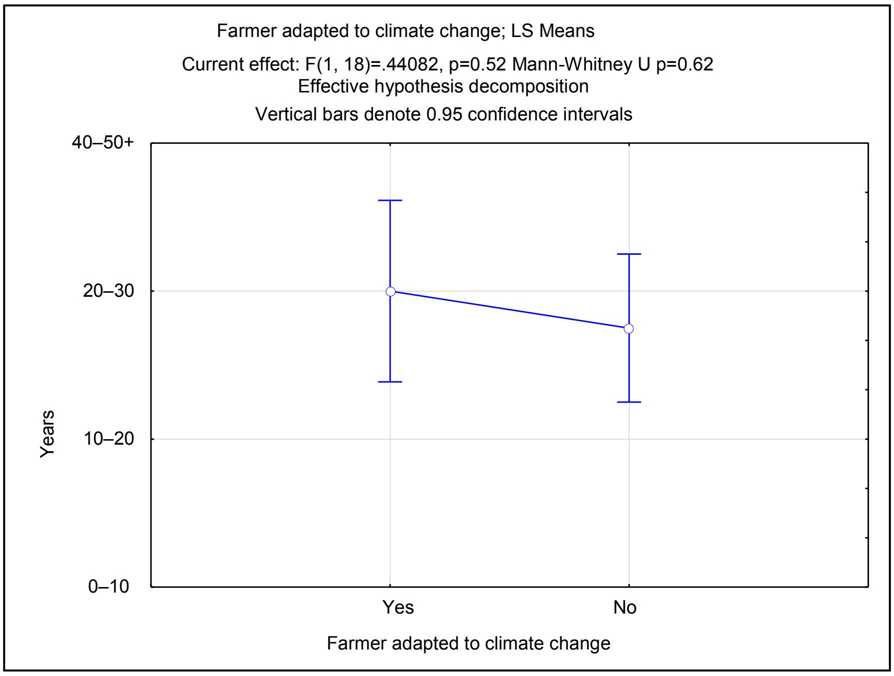

Figure 4.5: Farmers' adaptation to climate change where years of experience acts as a variable

4.2.4 Education

4.2.4.1 Question probed

Is there a relationship between farmers who have years of further education, and adaptation to climate change; to those farmers who have not studied further, and adaptation to climate change?

4.2.4.2 Results

Two definite groups were distinguished: (1) Farmers who studied further, and (2) farmers who did not study further. In order to make a significant conclusion P<0.005, where in this case P=0.58. The larger P value indicates no significant trend.

Table 4.9: Education and adaptation

	Descriptive statistics (subset in Heckman.stw)						
Effect	**Level of factor**	**No.**	**Mean**	**Std. Dev**	**Std. Err**	**-95.00%**	**+95.00%**
Total		20	2.900000	0.640723	0.143270	2.60013	3.199868
Farmer adapted to climate change	Yes	8	3.000000	0.534522	0.188982	2.55312	3.446872
Farmer adapted to climate change	No	12	2.833333	0.717741	0.207194	2.37730	3.289364

4.2.5 Access to credit

4.2.5.1 Question probed

Is there a relationship between farmers who have access to credit, and adaptation to climate change; to those farmers who do not have access to credit, and adaptation to climate change?

4.2.5.2 Results

Two definite groups were distinguished: (1) Farmers who have access to credit, and (2) farmers who did not have access to credit.

First group (1): 30% of the farmers adapted to climate change; the other 70% of the farmers who did not have access, did not adapt to climate change.

Second group (2): 60% of the farmers who have access to credit, adapted to climate change; the other 40% of the farmers who have access to credit, did not adapt to climate change.

In order to make a significant conclusion $P<0.005$, where in this case $P=0.25077$. A possible trend thus occurs where farmers have access to credit and adapt to climate change.

Table 4.10: Access to credit and adaptation

	Chi-square(df=1)=1.31, p=0.25213 Fisher exact, one-tailed p=0.25077		
Question 7.1.19	**Farmer adapted to climate change "yes"**	**Farmer adapted to climate change "no"**	**Row totals**
None	4	9	13
Row %	30%	70%	
Adapted	4	3	7
Row %	60%	40%	
Totals	8	12	20

4.3 Third section: Final Heckman Probit Adaptation Model results

This section presents the final results of the Heckman Probit Adaptation Model in which adaptation behaviour and experience (perception) of climate change were measured. The results are shown in Table 4.11. The independent predictor variables tested were membership of Water Management Associations, areas irrigated, years of farming experience, education level and access to credit.

Belonging to a Water Management Association, did not significantly influence farmers in experiencing climate change. Smaller areas irrigated and further education showed a slight trend of the possibility that farmers experienced climate change, but the random sample test was too small to see a significant trend. Years of farming experience influenced the probability of experiencing climate change in the Garden Route area.

Furthermore: Belonging to a Water Management Association, did not significantly influence farmers in the Garden Route area to adapt to climate change, yet a slight trend can be recognised due to the smaller P value. The random test was too small to deduce a definite behavioural change. Area irrigated, years of farming experience and education had no significant influence on the behaviour and adaptation of farmers to adapt to climate change due to larger P values. The random test for these independent predictor variables were too small to indicate the likelihood of adapting to climate change.

Access to credit measured as an independent predictor variable, however, resulted in a small P value P> 0.001. A significant trend can be recognized and it can therefore be deduced that access to credit, influence the behavior of adapting to climate change. Farmers with access to credit adapted to climate change.

Table 4.11: Results of the Heckman Probit Adaptation Model

		Coef.	Std. Err	z	P>|z|	95% Conf. Interval]
Adapted						
Water Management Association	1.662804	.8792407	.3997848	2.20	0.028	.095677
Area irrigated	.0029072	-.0028618	.0029434	-0.97	0.331	-.0086308
Years' experience	2.005776	.5428874	.7463853	0.73	0.467	-.9200009
Education	3.373676	1.352083	1.031444	1.31	0.190	-.6695104
Access to credit	1.303593	.8256997	.2438274	3.39	0.001	.3478068
Cons	5.909691	-5.497656	5.820182	-0.94	0.345	-16.905
Experienced						
Water Management Association	1.680116	-.1240113	.9204898	-0.13	0.893	-1.928138
Area irrigated	.0014084	-.0028269	.0021609	-1.31	0.191	-.0070622
Years' experience	2.05951	.9475179	.5673534	1.67	0.095	-.1644744
Education	2.242629	1.021098	.6232414	1.64	0.101	-.2004327
Cons	.1835217	-4.837434	2.561759	1.89	0.059	-9.85839

4.4 Conclusion

To conclude, the independent predictor variables tested in order to determine adaptation of farmers in the Garden Route area, were Water Management Associations, areas irrigated, years of farming experience, education, and access to credit. Some farmers adapted due to smaller areas irrigated; some due to years of farming experience and education, and a significant trend was farmers having access to credit. It resulted in the conclusion that farmers in the Garden Route, with financial support, adapted to climate change. The main adaptation strategies of these farmers included: changing the crop variety, automated irrigation, building water-harvesting facilities and keeping crop residues of the previous harvest on the land to preserve soil moisture, cooling the soil surface and stabilising soil temperature. These adaptation strategies and related challenges are discussed in Chapter 5. Interestingly similar studies have shown that changing crop variety, changing planting dates, increasing irrigation and buying livestock feed supplements were the main strategies farmers applied in order to adapt to climate change (adapted from Gbetibouo, 2009; Mendelsohn, 2000).

CHAPTER 5: **DISCUSSION OF RESULTS OF QUESTIONNAIRE AND THE HECKMAN PROBIT ADAPTATION MODEL**

The study examines how farmers' perceptions of weather conditions have corresponded with the climatic data, recorded at various meteorological stations in the Garden Route, South Africa. The study also analyses farmers' adaptive responses to, and perceptions of climate change, to determine if farmers' perceptions and adaptation measures are in line with climatic data records, as well as with the predicted southern Cape climate changes. In the third place, the study also examines to what extent farmers, in their perceptions of climate change and in their adaptation to it, if at all, have an understanding of the ethical challenges posed by climate change, and take this understandig into account if and how they respond to climate change.

According to Maddison (2006) adaptation to climate change requires farmers to identify that the climate has in fact changed, as well as to identify the necessary adaptation techniques. The primary hypothesis of this study with the farmers of the Garden Route area, is that farmers adapt to perceived climate change and variability. This analysis has been conducted in two stages. The first stage determined whether or not farmers perceive climate change and variability as a factor to consider in their agricultural farming practices, as well as the characteristics that differentiate between the farmers that did perceive climate change, and those that did not. The second stage investigated the adaptations of those farmers that did in fact perceive climate change. The determining factors of these adaptations were also examined. It is important to note that not all farmers who perceived climate change, responded with adaptation methods.

While Chapters 2, 3 and 4 have been used to present quantitative data obtained in the study, Chapter 5 will start with an interpretation of this data. In this Chapter I will first focus on the perception of climate change among farmers of the Garden Route area, and then move to a discussion whether, and if so, how farmers of the Garden Route area adopted measures to adapt to the perceived climate change. From Chapter 6 this interpretation will be taken further within the framework of a discussion of scenario planning focussing on adaptation to climate change, while links will also be made to the farmer's understanding of, and responses (or lack thereof) to the ethical dimensions of climate change.

5.1 Perception of climate change

To assess farmers' perceptions of climate change and variability, climatic data records obtained from the CSIR offices in Capte Town (August 2010) were investigated to see how trends and variability had evolved. In order to determine a perception of these trends, criteria were formulated to obtain a clear indication of how farmers perceive the climate.

Determining factors for the perception analyses included: years of farming experience, access to water and area under irrigation, access to accurate weather forecasts and information, types of farming methods, general observations of diverse changes (for example, the increase in pests and diseases), and observations of extreme events (for example, an increase in floods, fires, drought and extreme wind conditions).

Based on the information received from farmers on their perceptions of climate change, independent variables were selected. It was found that farmers, who do not practise conservation farming, are aware of climate change. On the other hand, farmers that do practise conservation farming are not aware of climate change as much as the farmers who don't. The reason for these results is because I deduce those farmers that already practise conservation farming have actually adapted to changing climatic conditions and do not experience the effects of climate change on the same level as those farmers who do not practice conservation farming. Farmers irrigating smaller areas also experienced climate change more than those farmers irrigating larger areas. The reason for this result relates directly to crops because those farmers that are irrigating smaller areas normally farm with vegetables and changes in climatic conditions reflect in their produce whereas farmers irrigating larger portions in this area are the dairy farmers who do not measure production against, for instance, a grazing crop.

Farmers were asked whether or not the change in temperature would be a factor to consider when planning future agricultural practices. Seventy per cent of the farmers felt that there is a slow, overall increase in temperature. Farmers also mentioned that the change in temperature influences the choice of varieties and cultivars for future planning. The increase of temperatures increases the rate of evaporation. Farmers placed great emphasis on the importance of suitable irrigation and irrigation techniques. Farmers were asked in what way they expect the maximum and minimum temperatures to change in the future (next 30 years). Fifty per cent of the farmers indicated an expectation for a general increase in temperature would continue in the future. In order to adapt to the temperature increase, 45 per cent of the diary farmers mentioned that they should purchase feed from other regions. Farmers relying on grazing said they would consider storing more feeds for animals. Forty per cent of the farmers indicated that the maximum and minimum temperatures follow a trend of both warmer and cooler periods; however, they were currently experiencing a warmer period. According to these farmers, the possibility exists that a cooler period might occur in 30 years from now. Fifteen per cent of the farmers indicated that they had no comment with regard to the prediction of future temperatures.

Farmers were asked in what way they foresee the rainfall patterns changing in the future (in the next 30 years). One hundred per cent of the farmers indicated that the rainfall pattern has changed. Fifty per cent of the farmers predicted that erratic rainfall patterns would continue. Thirty-five per cent of the farmers indicated that they are currently experiencing a dry period, and they predict the occurrence of further wetter and drier periods in the future. According to this 35 per cent of the farmers, there is a possibility that there could be a wetter period (as opposed to a drier period) in 30 years from now. Fifteen per cent of the farmers indicated that they had no comment with regard to the prediction of future rainfall patterns.

Farmers were asked whether or not they consider a change in the rainfall to be a factor when planning future agricultural practices. One hundred per cent of the farmers indicated that there is a change in the rainfall pattern and that rainfall had become more erratic. Most farmers formulated the change in the rainfall as an increasing variability.

According to the CSIR (2010), the data obtained from the Outeniqua Weather Station between the period of 1967 to 2008, indicates the general *increase* in both minimum and maximum temperatures over the years, in the Garden Route area. Rainfall data from the weather stations in Bergplaats, Herbertsdale, Karatara, Plettenberg Bay, Sandhoogte and Outeniqua; all indicated a change in average rainfall, but not necessarily a decrease in rainfall volume. However, between the period of 2000 to 2008, there was an indication of a *decrease* in rainfall figures for all the stations (mentioned above).

The Climate Change Strategy and Action Plan for the Western Cape (DEA&DP, 2008), recognise water and agriculture as one of the most vulnerable systems in the Western Cape under changing climate conditions. The Garden Route area is a prominent dairy and vegetable producing area (Eden Growth and Development Strategy, 2007). According to the farmers and literature (Botha, 2007), ryegrass, kikuyu and lucerne form the base of the dairy industry. Ryegrass produces optimally at an air temperature of 18 °C during the winter months and kikuyu at 21 °C. For each 1 °C increase in soil temperature above 18 °C, the dry matter production tempo for kikuyu will increase by 16 kg per day. The expected increase in temperatures, according to Global Climate Models, which predict a general increase of 1.5–2 °C in minimum and maximum temperatures, may therefore have negative implications for the productivity of these pastures. Increased temperatures also mean an increase in potential evaporation, which is likely to have negative effects on irrigated crop production (Schultze, 2007).

Future rainfall predictions by regional climate models indicate late summer increases in rainfall and a general increase in heavy rainfall events. According to the *Climate Change Strategy and Action Plan for the Western Cape* (DEADP, 2008), predicted trends include the following: a reduction in winter rainfall, late summer increases in rainfall and rainfall intensity, increases in magnitude of rainfall events in mountainous areas, increased variability of rainfall distribution and increases in humidity, especially during summer.

According to Schultze *et al.* (2005), these trends are likely to affect the timing and flow of rivers and streams, the recharge of supply dams, groundwater recharge, water quality, as well as the frequency and intensity of floods. The periodic floods and droughts over the past years led to significant economic losses in the Garden Route area. During drought episodes, grazing security, supply of water and job losses, had been some of the most significant impacts identified by the *Climate Change Strategy and Action Plan for the Western Cape* (DEADP, 2008).

If agriculture in the Garden Route is to overcome anticipated climate change which is predicted to cause more climate variability, floods and droughts, it urgently needs to adapt land and water management practices. The study identified that approximately 65% of the farmers who were interviewed indicated perceptions that are in line with climatic data records for the Garden Route area, with temperature and rainfall patterns as the main indicators. However, not all these farmers responded with adaptation strategies or methods.

5.2 Adaptation to climate change

According to Mendelsohn (2000) and Gbetibouo (2009), adaptation is widely recognised as a vital component of any policy response to climate change. Studies show that without adaptation, climate change is detrimental to the agriculture sector; however, with adaptation, vulnerability can be reduced largely (Gbetibouo, 2009).

According to the IPCC (2012), the degree to which an agricultural system is affected by climate change, depends largely on its adaptive capacity, which entails the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damage, take advantage of opportunities, or to cope with the consequences (Gbetibouo, 2009). The adaptive capacity of a system or society describes its ability to modify its characteristics or behaviour, so that it can cope better with changes in external conditions

(Gbetibouo, 2009). According to Maddison (2006), adaptation to climate change requires that farmers first perceive climate change, and then identify useful adaptations and implement them.

However, agricultural change and adaptation does not involve a simple linear relationship between changes in a farmer's decision-making environment and farm-level change (Maddison, 2006). A farmer may perceive several hot summers and rationally attribute them to climate variability and not climate change over a long term.

According to Belliveau (2006), empirical assessment of actual adaptive behaviour is place- and time-specific, and more likely represents a response to interperiodic climatic variability, as well as to multiple non-climatic risks and opportunities. Understanding farmers' likely adaptive responses to anticipated climate change represents serious challenges for researchers. One major challenge is to isolate the climate stimuli response from other stimuli (market, technology, policy, etc.), that farmers face in the real world (Gbetibouo, 2009). Secondly, farmers are more concerned with and respond more to short-term climate variability than climate change. However, the ability of farmers to cope with current climate variability is an important indicator of their capacity to adapt to future climate change.

Even though a large number of farmers interviewed in the Garden Route noticed changes in the climate, approximately two-thirds did not take any remedial or adaptive action. Main constraints cited by farmers in changing their ways of farming and adapting to climate change were: obtaining rights to increasing their water storage capacities (expanding dam walls or building dams), flood water management, cash flow and financial support, obtaining permits to burn, and general support from official structures.

A further constraint that was mentioned by the farmers is to change the farming methods to more sustainable practices. For many decades, nitrogen fertilizer had been a driving force behind optimum production. Due to increasing social and economic pressure to use environmentally-friendly products, farmers have to think carefully before applying nitrogen to their crops. To manage alternative sources of nitrogen is a difficult task and has financial implications.

Another financial cost is to increase the carbon level of soil. Markets (local and overseas) demand certain specifications that farmers must fulfil before a product can be sold. According to the famers that export their products such as vegetables certain certificates such as Eurogap and Leaf[15], must be obtained in order to qualify as a producer. Farmers are encouraged to adjust their farming practices in such a way that they maintain or increase the organic component in the soil on the one hand – which includes that practices that hasten the oxidation of carbon, such as burning crop stubbles or over-cultivation, are discouraged.

On the other hand, farmers are also encouraged to incorporate organic material increasing soil carbon. This is not a straightforward task as it is made complex by the relative activity of soil biota, which can consume and release carbon. According to some of the farmers, the reason why this adaptive practice is so important from a climate change perspective is that soil carbon improves the physical properties of soil. It increases the water-holding capacity of sandy soil and it contributes to the structural stability of clay soils by helping to bind particles into aggregates. Furthermore, soils have the ability to retain carbon that may otherwise exist as atmospheric carbon dioxide, and contribute to greenhouse warming.

The independent predictor variables tested in this study in order to determine adaptation of farmers in the Garden Route area were: Water Management Association membership, areas irrigated, and years of farming experience, education, and access to credit. Some farmers adapted because of smaller areas irrigated; some due to years of farming experience and education level, and a significant trend was farmers having access to credit. It resulted in the conclusion that farmers in the Garden Route, with financial support, adapted to climate change.

The main adaptation strategies of these farmers include: changing crop variety, automated irrigation, building water-harvesting facilities and keeping crop residues of the previous harvest on the land to preserve soil moisture, cooling the soil surface and stabilising soil temperature. Similar studies have shown that changing crop variety, changing planting dates, increasing irrigation and buying livestock feed supplements were the main strategies farmers applied in order to adapt to climate change (Gbetibouo, 2009; Mendelsohn, 1998).

5.3 Adaptation strategies and mitigation

Table 5.1 represents adaptation and mitigation strategies for the Garden Route area that were investigated.

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[15] http://www.greenleafecostandard.net/faq.html

http://www.agricultureinformation.com/forums/wanted/49690-eurogap-global-gap-farms.html

Table 5.1: Adaptation and mitigation strategies that were investigated in the Garden Route

	Adaptation strategy	Comment
1.	Changed crop variety	Most farmers have adapted
2.	Automated irrigation	Expensive
3.	Implement soil conservation techniques	Expensive
4.	Buy insurance or insure farm	No structure in place; limited opportunity
5.	Reduce number of livestock	Only during drought
6.	Lease land	Not necessary in most cases
7.	Find off-farm job	Not necessary in most cases
8.	Build a water-harvesting facility	Farmers would like to increase their rights to build more dams
9.	Change amount of arable land	Some farms in process, but expensive
10.	Change planting date	
11.	Livestock feed supplements from off-farm	Only during drought times
12.	Resort to more heat-tolerant breeds rather than traditional ones	Make use of advice and research
13.	Change the timing, duration and location of grazing	Expensive; not always possible
14.	Increase application of chemicals (such as Erian) to slow down evapo-transpiration	Most farmers have adapted to better environmentally-friendly processes
15.	Apply more organic fertilisation to retain moisture content and fertility of soil	Most farmers have adapted
16.	Keep the crop residues of the previous harvest on the land to preserve soil moisture, cool the soil surface and stabilise soil temperature	Most farmers have adapted; but finance is a barrier
17.	Sink your own borehole(s)	Water in the area tends to be brackish; potential environmental damage.
18.	Make use of a floodplain for agricultural production	Farmers feel this is a survival remedy
19.	Use credit to buy new technology	Most farmers cannot afford to adapt to the latest technology
20.	Other	Increase of soil carbon level; expensive, healthier and more productive soils can contribute to positive socio-economic circumstances

Table 5.2 represents possible adaptation strategies suggested by farmers.

Table 5.2: Possible adaptation strategies suggested by farmers

Adaptation strategy	Comment
1. Incentives to use less water. Farmers indicated floodwater management needs serious attention, because 80% of the run-off flows into the sea. Farmers who act in a sustainable way, with regard to water usage, should receive a subsidy.	Possibly limited opportunity; needs institutional framework
2. Increase use of grey water	Potentially expensive
3. Accurate weather forecasting	Increasingly feasible
4. Increased water-use efficiency and water recycling	Possibly expensive to upgrade
5. Catchment management to reduce polluting run-off	Requires buy-in from farmers – for example, incentives
6. Improved flood warning and dissemination	Technical limitations in flash flood areas and unknown effectiveness
7. Curb floodplain development	Potential major socio-political problems
8. Change crop pattern	Change to crops which need less or no irrigation
9. Increase flood protection (levees and reservoirs, dams)	Expensive; potential environmental impacts
10. Goal-orientated research and the practical usage thereof, is a necessity and needs to be addressed.Better communication and feedback on improving agricultural methods and adapting to climate change.	Needs institutional framework
11. The taxing of agricultural land needs attention; it can be used to assist farmers in sustainable farming practices, taking climate change into consideration. Garden Route region to be a farming area taking climate change into account.	Needs institutional framework, support from government
12. Climate change information centre	Needs institutional framework, funding

5.4 Conclusion

As seen in the table above, farmers indicated that institutional frameworks, support from the government, technical support and funding are needed to achieve a positive outcome for possible adaptation strategies for farmers in the Garden Route. Chapter 6 provides the results of two workshops that were held (one with farmers, the other with specialists) where these examples and possibilities were discussed in order to reach practical solutions.

The statistical analysis of temperature data from 1967 to 2008 in the Garden Route area (Chapter 3) shows trends of increasing temperatures and variability in rainfall. Most of the farmers' perceptions of climatic variability are in line with climatic data records, and are able to recognise that temperatures have increased, as well as a change in rainfall patterns. Farmers irrigating smaller areas experienced climate change more than those farmers irrigating larger areas. With more experience, farmers are more likely to perceive change in temperature.

Although farmers are well aware of climatic changes, few seem to take steps to adjust their farming activities. Only approximately one-third of the farmers have adjusted their farming practices to account for the impacts of climate change. The main adaptation strategies of farmers in the Garden Route area include: changing crop variety, automated irrigation, building water-harvesting facilities, keeping crop residues of the previous harvest on the land to preserve soil moisture, cooling the soil surface and stabilising soil temperature. Farmers indicated that these adaptation strategies are mostly in reaction to experience and can be described as "reactive strategies". This can be seen as positive adaptive behaviour as a result of experience due to impacts of climate change on production.

The Heckman Probit Adaptation Model was applied to examine the determinants of adaptation to climate change and variability. The results highlight that farm size, years of farming experience and access to credit are the factors that enhance adaptive capacity to climate change. Government policies should therefore strive to ensure that farmers have access to affordable credit so that they can increase their ability and flexibility to change production strategies in response to the forecasted climatic conditions. Irrigation investment needs should be reconsidered to allow farmers increased water control to counteract adverse impacts from climate variability and change. To promote efficient water use, emphasis should be on pricing reforms. The uncertainties of climate change and variability are limitless – both in the number of strategies and in the combinations of management measures that comprise a strategy. The Intergovernmental Panel on Climate Change (IPCC, 2012), highlights six reasons to adopt adaptation strategies to possible climate change, irrespective of when, where and if climate change is going to impact a certain region:

1. Climate change, or the effects of it cannot be totally avoided.
2. Anticipatory and precautionary adaptation is more effective and less costly than forced, last-minute, emergency adaptation or retrofitting.
3. Climate change may be more rapid and more pronounced than current estimates suggest. Unexpected events are possible.

4. Immediate benefits can be gained from better adaptation to climate variability and extreme atmospheric events.
5. Immediate benefits also can be gained by removing maladaptive policies and practices.
6. Climate change brings opportunities as well as threats. Future benefits can result from climate change.

Finally, there is a clear need for improved recognition of the fact that the world is rapidly changing. Government and, ultimately, individuals, should adjust, show resilience and develop effective adaptive responses to changes in climatic conditions, as well as adapt ways of thinking, acting, farming, and managing vital resources such as water. In the Garden Route farmers are mostly in a "reactive" state when it comes to adapting their agricultural practices. The recent drought period has made most of the farmers aware of the water scarcity in the area, yet many have in previous years when the rainfall was sufficient, not considered the same adaptation measures. Most of them have indicated, as discussed in this chapter, that there is a need for government and structural support in order to address climate change and extreme events in future. This need is discussed in Chapter 6 with recommendations to secure more sustainable farming in the area.

CHAPTER 6: **WORKSHOPS, SCENARIO PLANNING EXERCISE AND RECOMMENDATIONS**

6.1 Overview and methodology

Sustainable land and water management in South Africa is more critical today than ever before. Crop output is declining, and water management and storage infrastructure are desperately needed in order to fast track and sustain socio-economic development in the Garden Route area (person. comm. H. Muller, 20 September 2010). Discussions are long overdue in finding solutions that charter a path into a future that guarantees sustainable food production, together with sustainable management of the environment and resources taking climate change into account. The first part of this study examined farmers' perceptions of weather conditions and adaptive responses to climate change. Ethical challenges were highlighted, and as part of the study and search for a ways forward in the Garden Route, this study has involves a second part which involves a scenario planning exercise. The reason for this exercise is to sketch four possible scenarios that the Garden Route area may encounter with reference to climate change, agriculture and moral issues as seen in the first part of this study. In taking as point of departure the results that were obtained during the first part of the study, this second part of the study aims to report on input from a second round of comments from farmers, specialists and recommendations to the state and the farming community for future adaptation projects and ways to deal and address moral issues with specific reference to water issues in the Garden Route area.

The methodology for the second part of this study involved the two workshops and a scenario-planning exercise as discussed in Chapter 1.

This chapter focuses firstly on the feedback and comments obtained from the five farmers that attended the first workshop that was held on the Saasveld campus, and secondly, it focuses on the feedback and recommendations obtained from the specialists that attended the second workshop at Kirstenbosh. As mentioned earlier on, the purpose of both these workshops was to focus on the results obtained from the first part of this study and to provide possible solutions for wiser agricultural practices in the Garden Route taking climate change, perceptions and adaptation methods into account according to four possible scenarios that the Garden Route area might encounter in the future.

6.2 Discussion: First workshop, Saasveld 15 June 2010

During this workshop a few topics were discussed before the farmers were asked to complete the scenario exercise. The topics related to (i) water usage in the Garden Route, (ii) irrigation systems, (iii) alien management, and (iv) adaptive methods to address the water situation in the Garden Route area. A summary of the discussions during this workshop is provided below.

6.2.1 Views on water usage

The farmers that attended the workshop formulated the change in the rainfall as an increasing variability and mentioned that the change in rainfall made it difficult when planning their future agricultural practices. Farmers emphasised the need to obtain permission to increase storage and dam capacity. During this current dry period, farmers have found themselves to be operating in a "survival mode", and in some instances, farmers have expanded their dam walls illegally – due to a long waiting period of authorisation, and due the lack of government support or a funded state scheme such as the Orange River scheme, Berg River dam, and Lesotho-Highland scheme.

Farmers mentioned the dilemma in which they found themselves as they are aware the sub surface water needs to be considered. They also indicated that the natural flow should not be changed and that technical people (experts) would need to consider the overflow into the sea before they can start to construct dams on their properties or expand their dam walls. This constant conflict between "right and wrong" about what to do with regard to water storage was raised as a moral issue by the farmers. They also indicated that the perception that dams are negative is debatable. In order to demonstrate this point farmers discussed a water study that was considered for the Knysna River ten years ago. However the municipality deemed to not have sufficient funds or the need to have proceeded with the study. Farmers indicated that private studies have been performed and have not been considered, thus leaving the responsibility on the farmers to make their own plans. There was a unanimous outcry from farmers to the Department of Water Affairs to assist them in obtaining permission for building more storage dams on their farms. In response to this request, Mr Rashid Khan (Regional Director, Western Cape) called for a meeting with the National Planning Team to be held on the 3rd of August 2010, in the Eden District, to deal with and fast track all applications for new storage dams as part of the declared disaster area. The request by farmers was that the limitation of 50 000 m^3 for a dam should be increased to 200 000 m^3. No decisions were taken at this meeting and any decisions made are therefore considered arbitrary.

Farmers indicated that the quest for wise water use in the Garden Route has become a serious moral issue. Farmers experienced that the two recent years of drought, were preceded by two years of flooding. If the farmers are able to stock the excess water from one year to feed the lower rainfall the following year, they indicated that there will in all likelihood be less illegal practices. In practice, farmers struggle to farm effectively. When a farmer captures water in limited storage capacity during heavy rainfall, the excess water cannot be captured and flows straight into the sea. When there is less rainfall, a farmer still has limited storage capacity and results in using much less water.

Farmers indicated that this is not a sustainable way to farm. Heavy rainfall results in excess waste and little rainfall results in the need to save water. Therefore, without effective storage, even when there have been high rainfall figures, farmers indicated that there is sparse usage and excess waste.

6.2.2 Irrigation systems

Farmers also mentioned that a possible way to address the water shortage in the Garden Route area is to reconsider irrigation systems that are currently used on farms to also look at subsidised systems. For example, in India, farmers are subsidised; in South Africa, farmers are not subsidised and it becomes a very expensive exercise. From experience, a farmer concluded the following: "*I save water with a different irrigation system that I used during previous years. Financial costs are high to uphold the system and that affects the total cost of production. This is the dilemma. The State could assist us by supporting or subsidising with irrigation, which effectively would help us save water. A drip system underground does work, but it depends on the soil; it needs the right soil profile. Currently it costs R12 000 to R15 000 per hectare. The drip system needs to be taken out and replaced every six months.*"

Farmers indicated that if they were subsidised, this would help them greatly. Instead, farmers have to take the initiative and do it themselves. They are afraid to apply a new system to the farms, based on experimental experience, as opposed to scientific results. This would be dangerous, because this would mean that each farmer would incur a high risk. It is more than just water; there is also impact on the infrastructure. The question that farmers find themselves asking is: "*Can I, year by year, continue with the system and remain effective?*"

6.2.3 Alien vegetation management

Another possible way to address the water shortage in the Garden Route area in the long term is to look at alien vegetation management in the area.

According to farmers, alien management is not a “hit-and-run” process it is a long-term process with sustained input. Landowners are responsible for alien vegetation management; however, not all farmers currently effectively adhere to this responsibility. Farmers mentioned that the problem should be looked at holistically. Farmers placed emphasis on the fact that in order to control invasive vegetation effectively, they need to have a plan. If invasive vegetation is taken out indiscriminately, it leads to other problems, such as erosion and top soil run-off. Invasive vegetation must be replaced with suitable vegetation. Erosion becomes a problem if a farmer just removes the invasive vegetation. Practically, removing invasive vegetation is different for each area. Some areas are cleared on a regular basis. Farmers have questioned if the state is doing its role in removing invasive vegetation on their land.

Farmers indicated that rules have been laid down to promote alien control, but these rules are not always followed through. Although suppliers should check the clearing and award certificates, it does not always happen. Farmers indicated that there needs to be certain level of commitment from the farmers. This is a personal commitment. The natural system is influenced all around. If only one area is cleared, it does not work, as the un-cleared vegetation areas infest the cleared area.

6.2.4 Adaptive methods to address climate change and water availability in the Garden Route

Farmers indicated clearly that there is a difference between short- and long-term adaptive practices. Short-term practices include experimental risk assessments by farmers such as switching to different irrigation systems, other cultivars, etc. Long-term adaptive practices would include a total change in farming practices, i.e. to farm with ostriches, game, etc. instead of vegetables. One farmer’s response was that considering alternative crops currently involves *thinking* about it, but not *doing* it as climate change is such a broad concept. The farmer stated that it is too early to change, but considering other possibilities should become any farmer’s priority. More research is required in order to help farmers consider new methods and possible crop changes in this region to adapt to climate change and water availability. According to farmers, the large-scale farmers can adapt as they have the available resources and capital whereas the small-scale farmers cannot adapt. These small-scale farmers are forced to adapt using other methods, scaling down, farming less, selling off their land or moving to other regions. One farmer noted that if he moves his farming stock from the Garden Route region, he would need to move to an area where there is a state water scheme in place. This becomes increasingly difficult because areas like the Garden Route have little or no state investment, acting as a support to farmers.

One farmer indicated that he is already in the process of moving his stock (cows) to the northern parts of the country, in agreement with another farmer, who is already farming there. Farmers' frustrations are evident as they also foresee that in the next ten years, the legislation will not change and the expertise may not be replaced as required. The one farmer quoted: "*One has to be open and see that this is a reality that probably would not change. One needs to adapt and consider what the options are.*"

Farmers indicated that the main barriers to adaptation manifest in many ways. Land is very expensive and it is forcing some farmers to scale down and sell off certain parts of their farms. The market also has a huge influence on ways of adaptation, and climate change on its own has brought along many changes in ways that farmers think. Not all famers have adapted to climate change in practical ways but what was evident from the workshop was that currently farmers are the ones who have to plan for less water. Farmers are trying smaller experimental patches of land with various crops. This is a financial risk, but it does give the farmers a better idea as to what works and what does not.

In conclusion, a farmer said: "*Questions regarding the future are tempered by optimism – perhaps we are just blind. If the decision were only reliant on water, it would be easy to make a decision on whether or not to continue. However, temperatures, markets, products and workers all play a significant role and create various barriers and moral choices in the way one plans for the future."*

6.2.5 Discussion of four scenarios

As part of this first workshop farmers were asked to evaluate the following four possible scenarios that the Garden Route might encounter according to the results obtained from the first part of this study and together with their own personal experience. Farmers were asked to make use of a significance matrix rating from: *unlikely, less likely and likely* to indicate the actions that they perceive farmers would most likely follow according to the following four possible scenarios:

- If agricultural practices continue as per status quo – with no change foreseen in climatic conditions.
- If agricultural patterns are significantly modified, to reduce agricultural impact on local biodiversity – with no changes foreseen in climatic conditions.
- If agricultural practices continue as per status quo – with significant change in climatic conditions foreseen.
- If agricultural practices are significantly modified, to reduce agricultural impact on local biodiversity and taking account of likely changes in climatic conditions foreseen.

Farmers were provided with all the information relating to climate issues and possible adaptations. They had to indicate the likelihood of the future trend according to the matrix provided. The matrix and rating scale was agreed on in conjunction with the terms of reference from WESSA to determine possible behaviour according to the four possible future scenarios for the Garden Route. The core criteria determining the extent of the likelihood of the potential actions as provided to the farmers were merely to indicate how they perceive the possibility of certain actions and to determine possible adaptive behaviour according to the scenario. During this exercise it was determined that should agricultural practices continue as per status quo with no change in climatic conditions (Scenario 1) it seems that farmers will in all likelihood continue to increase storage capacity and build more dams, it is less likely that alien removal will take place, and it is unlikely that famers will consider other varieties and cultivars. If agricultural patterns are significantly modified, to reduce agricultural impact on local biodiversity with no change in climatic conditions (Scenario 2) it was noted that the likelihood that famers might consider alternative crops in the Garden Route to adapt to the climate was one of the most significant results. The likelihood that farmers would carry on to increase storage capacity was rated as “less likely”, and the reason for this is the change in agricultural patterns. Should agricultural practices continue as per status quo with significant change in climatic conditions (Scenario 3) the likelihood that famers would increase storage capacity and build dams was rated as “likely”, indicating that problems that famers encounter at the moment will still be present should this be the scenario for the future. If agricultural practices are significantly modified, to reduce agricultural impact on local biodiversity and taking account of likely changes in climatic conditions (Scenario 4) it was noted that farmers would adapt and the likelihood to increase storage capacity would decline, and alien removal would be more likely. This exercise demonstrated that with no change in climatic conditions, but a change in farming practices towards environmental protection, the farming sector may achieve sustainability. However, if climatic conditions should change significantly, current changes in farming practices may be insufficient to guarantee its sustainability.

6.3 Discussion: Second workshop, Kirstenbosch 15 June 2010

A second workshop was held where the specialists (a biologist, climatologist, sociologist and an agricultural economist[16]) gave input, with reference to the above-mentioned scenarios and with the aim of addressing issues raised by farmers during the survey. The following section summarizes most of the significant contributions that were made during this workshop.

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[16] Refer to footnote 5 for credentials.

All the specialists agreed that the Garden Route region has variable rainfall and the constant pattern from previous years has changed. They added that projections of climate change impacts (rainfall, temperature and extreme events), remain speculative, although strong trends have been detected in the physical environment, for example the rising of the sea level and warming parts of both the Agulhas and the Benguela Current (DiMP, 2007). Specialists advised that ways to address the variable rainfall pattern should include better water management especially during extreme rainfall events and dry periods, an improvement in habitat management and the realization that competition for urban development is evident and the balance between agricultural needs and urban requirements needs to be addressed. Specialists indicated that management of the whole Gouritz Water Management Area needs a holistic approach. The issue of more dams and more water storage was raised and the overall question of what the long-term implications would be, was asked. The specialists stipulated that there would be a definite negative impact on biodiversity and soil should more dams be built without proper assessment of what the long term consequences would be. Furthermore the issue was raised whether the lack of storage would lead to more unlawful practices such as activities in floodplains, illegal pumping from rivers or raising of dam walls, and what the risks and vulnerabilities involved would be.

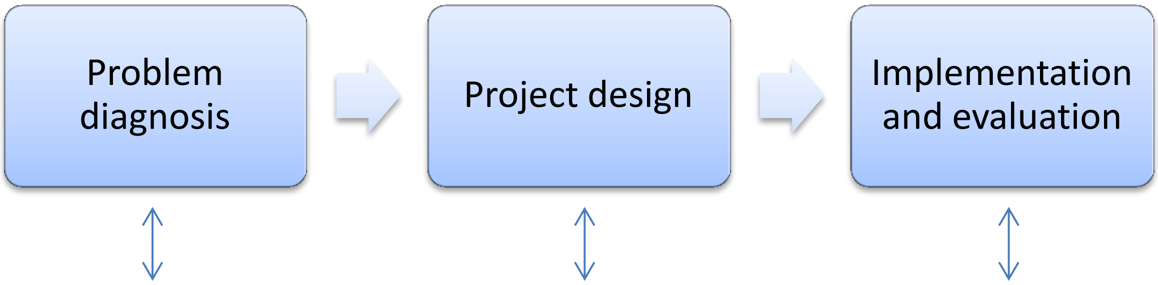
The specialists highlighted that there needs to be more focused research and assessment of risk and vulnerability of the agricultural sector in the Garden Route. The sustainability of agriculture in the region should be addressed and focus should be on current unsustainable farming and adaptation measures, which involve further risk to farmers. Land use change in the area (e.g. from agriculture to game farming, golf courses and selling off land to developers of residential housing) are considered unsustainable ways to adapt to climate change. The specialists indicated that there a need to investigate in this regard who would be the best entity or entities to conduct such research to determine the most sustainable landuse(s) in the region. It is important that an objective, dispassionate team evaluate the full impacts of current and future storage structures on natural ecosystems, particularly the already stressed rivers and estuaries in the Garden Route region, seeing that at least 95% of rivers in the Western Cape are in an endangered or critically endangered state as referred to in Chapter 1 and also emphasised during the workshop. The specialists provided the following recommendations with reference to the above:

- The possible impact of climate change will require adapting the management of the agricultural sector. Farmers can set up test groups (consisting of farmers) aiming to implement certain recommendations. The purpose of one test group, for example, is for the farmers to carry the shared risk in trying out some adaptation strategies (e.g. trying new crops or cultivars). The farmers will receive information or advice on possible adaptation strategies, share the risk, and in return for the information or advice supplied, commit to sharing the outcomes of their experiment in dialogue- or information-sharing workshops with other farmers. In this manner, a collaborative and information-sharing approach between farmers will hopefully be pioneered. If the test group is successful, other farmers will ideally see the benefit of working together and/or sharing information.

- Taking the above-mentioned into account, farmers in the Garden Route could consider the possibility of alternative, more suitable crops (long-term adaptation).
- Farmers should consider sustainable farming practices which might entail, for example a change to micro or drip irrigation.
- Farmers should conserve the Palmiet grass and Peet soil on their land, as it serves as a sponge during times of intense flooding. The removal of alien-invasive species should become a priority, replacing it with a natural substitute, such as the Palmiet grass.
- Farmers planning to plant and harvest lucerne in the Garden Route could register with a local municipality as a fodder producer. This action will provide further long-term and predictable estimates for all the other role-players in the crop value chains. It would also aid other farmers dependent on buying food for their livestock to possibly lessen the “food miles”, should they be able to buy food closer to their farms.

Many production sectors in the Garden Route are already impacted upon by climate variability, thus making it important for the long-term success of development assistance. Specialists indicated that stakeholder involvement is critical as local knowledge and memory of climate change over time, and can help identify adaptation options and the implementation thereof. With reference to Scenario 4, anticipating climatic variability and change while designing resilience into development assistance, can lead to more sound and accurate agricultural projects that serve the Garden Route region better.

To achieve the establishment of more sound and accurate agricultural projects as advised during the workshop, guidelines for possible future projects or initiatives in the Garden Route were used that are based on research done by the International Resources Group in 2007 (IPCC, 2007) in the USA. This sequence is viewed as a cycle owing to the dynamic nature of assistance: the completion and evaluation of one project could provide the impetus for a subsequent project to build on the previous project’s accomplishments, or address issues that were absent in the previous design, or emerged over the course of implementation.



Step 1:	**Step 2:**	**Step 5:**
Screen for Vulnerability	Identify adaptations	Implement adaptations
	Step 3:	**Step 6:**
	Conduct analysis	Evaluate adaptations
	Step 4:	
	Select course of action	

Figure 6.1 General Project Cycle (IPCC, 2007)

Step 1: Screen for vulnerability: Vulnerability screening is a preliminary assessment of whether climate variability or change could compromise the integrity, effectiveness, or longevity of a project within the agricultural sector of the Garden Route.

Step 2: Identify adaptations: Work with farmers, state departments and municipalities to identify alternative designs or management practices that may enable them to cope better with climate variability and change.

Step3: Conduct analysis: Examine the consequences of climate variability and change as well as the effectiveness, costs, and feasibility of adaptations that can reduce vulnerability to climate variability, and change stakeholders to review results of the analysis.

Step 4: Select course of action: Meet with farmers to review the results of the analysis. Determine if changes in a current project design are required or if a proposed project should feature new adaptations or strategies.

Step 5: Implement adaptations: Prepare an implementation plan identifying the following steps, responsible staff and organisations, timeline, and resource needs required to incorporate the climate change adaptations into the project or initiative.

Step 6: Evaluate adaptations: Evaluate the implementation of adaptations or strategies and their effectiveness. Since many adaptations may be due to infrequent extreme events or long-term climate change, it may be difficult to evaluate effectiveness in a relatively short period, following implementation. But, at a minimum, an evaluation can be done to see if the adaptations were put in place and whether there were problems or excessive costs associated with them.

From the research conducted for this study, feedback from farmers and recommendations obtained from specialists the following four main categories of vulnerability (Figures 6.2 to 6.5) were identified in the agricultural sector of the Garden Route to climate variability and change in terms of Step 1 of the project cycle above. Possible projects or initiatives and solutions, as recommended by specialists, can form part of future adaptation processes and strategies for this region, together with recommendations made under Step 5. Specialists indicated that to address water and alien management in the Garden Route region a possible Payment for Ecosystem Service (PES) project (Cumming, 2010) could be piloted in the area (Refer to Figure 6.3).

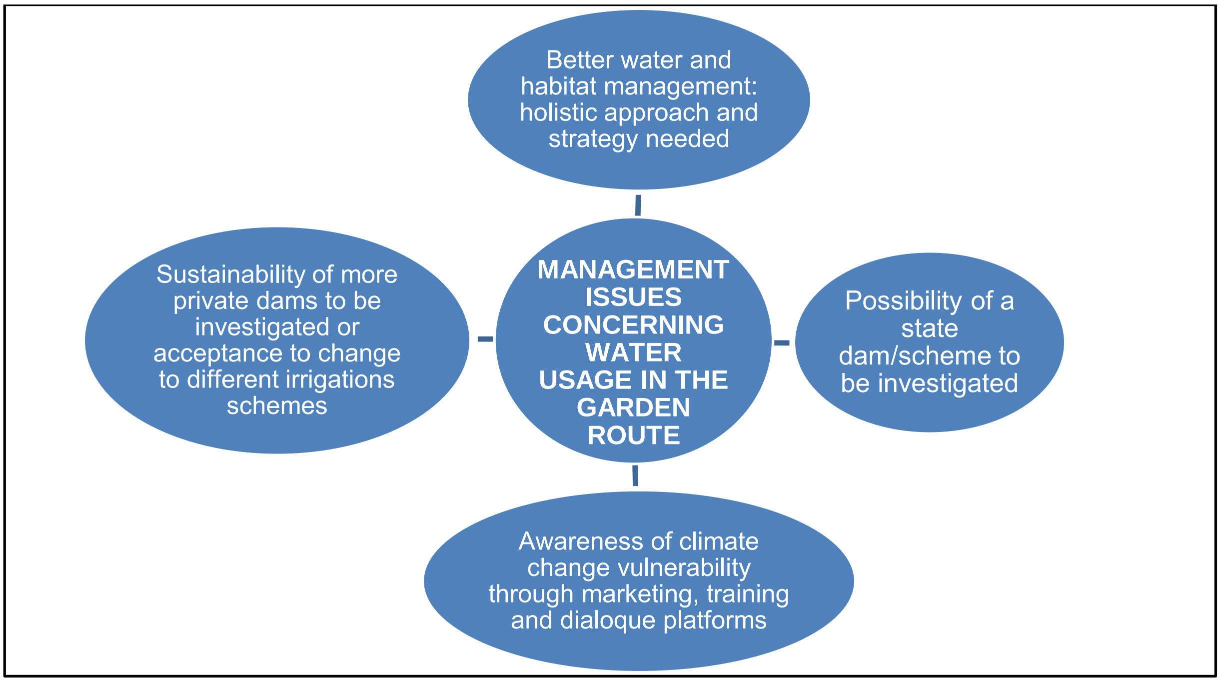


Figure 6.2: Water usage in the Garden Route

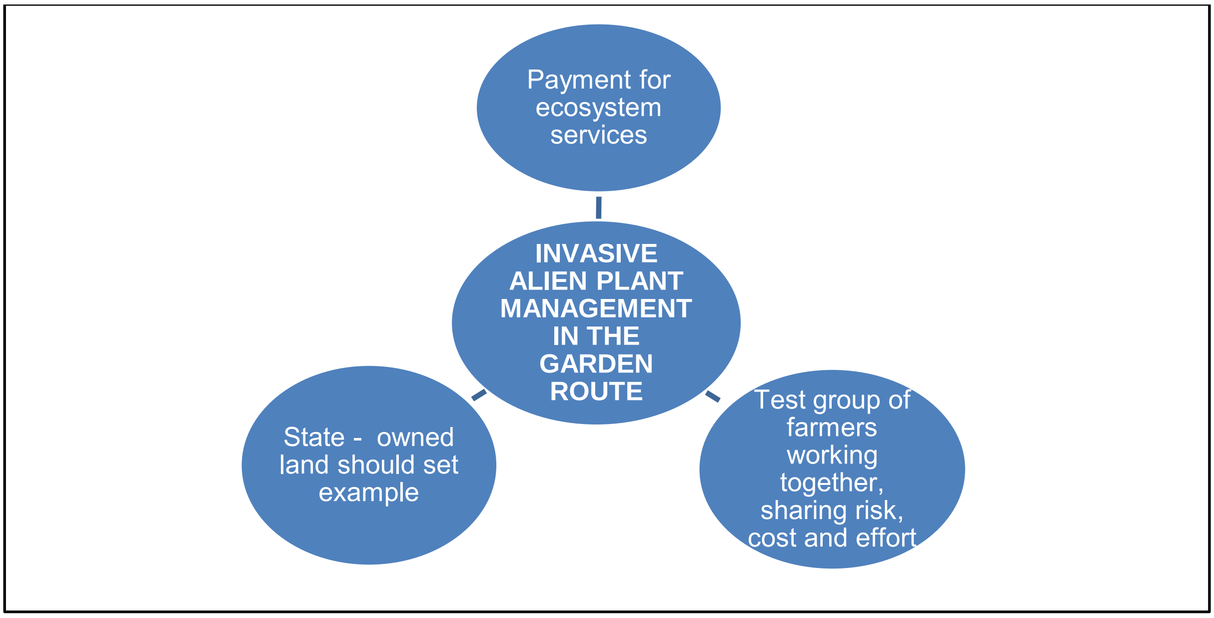


Figure 6.3: Invasive alien plant management in the Garden Route

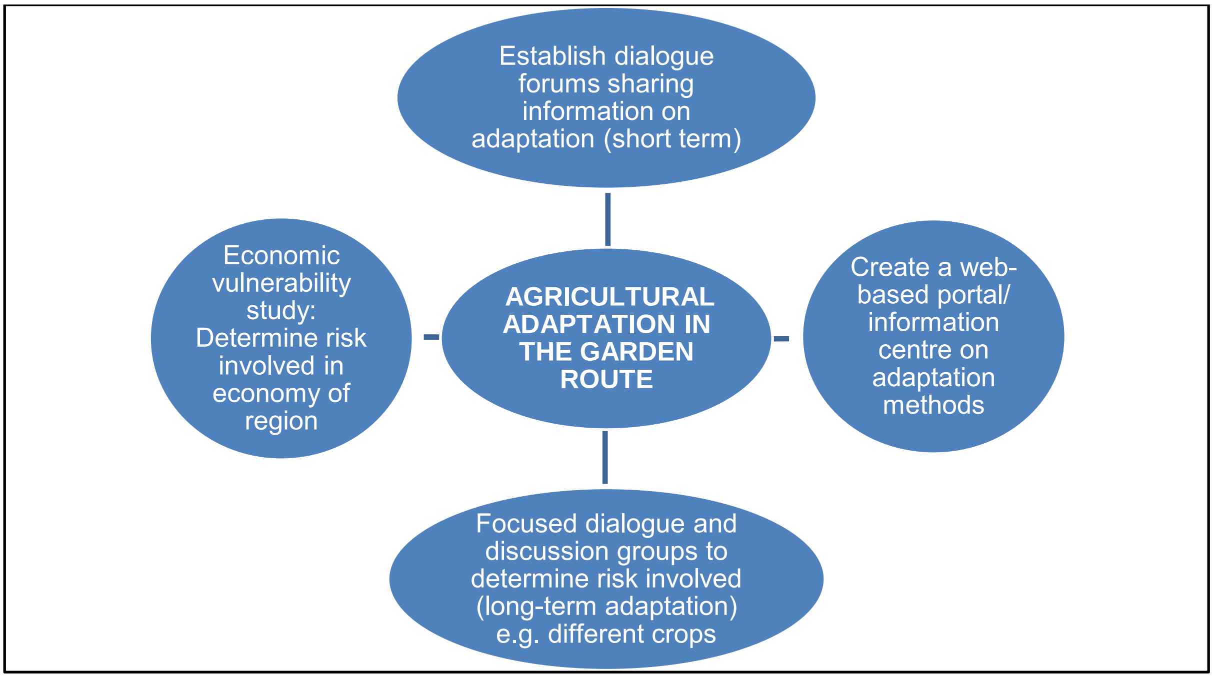


Figure 6.4: Agricultural adaptation in the Garden Route

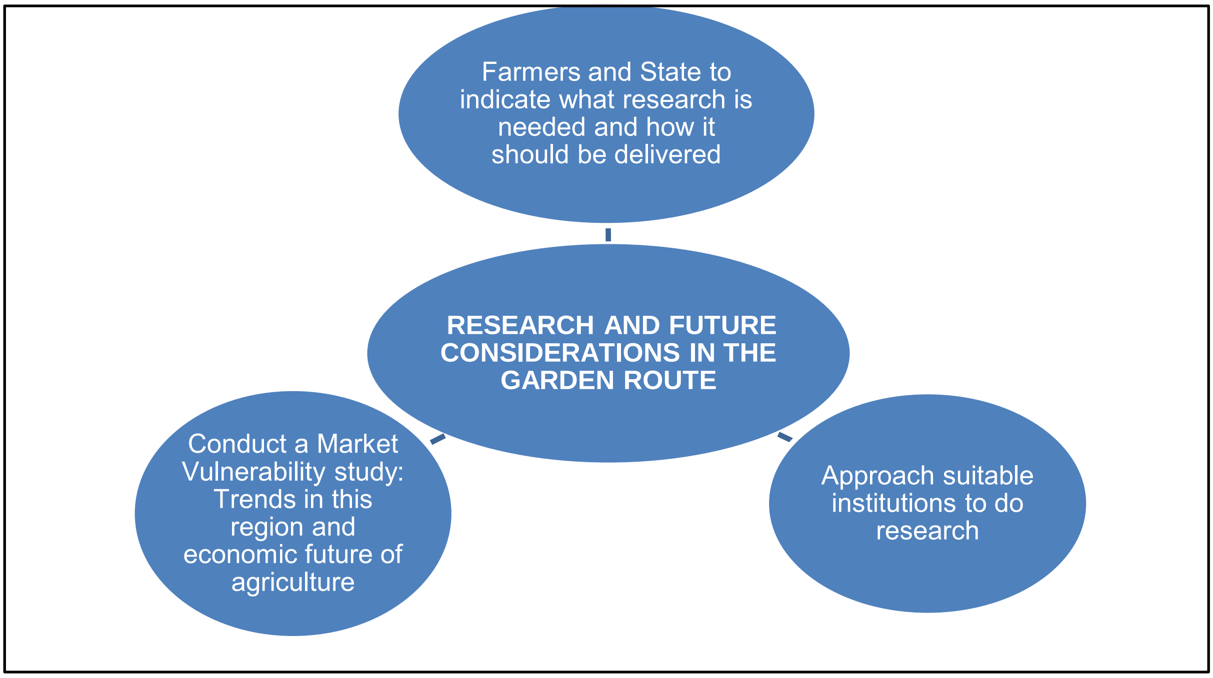


Figure 6.5: Research and future considerations in the Garden Route

The fundamentals for a PES project involves a market area, marketing e.g. products made of invasive alien plants, zones of cost and benefit and a good understanding of the water extraction by invasive alien plants and the implications for the agricultural sector.

PES, also known as Payments for Environmental Services (or Benefits), is the practice of offering incentives to farmers or landowners in exchange for managing their land to provide some sort of ecological service (Cumming, 2010). These projects promote the conservation of natural resources in the marketplace such as in the case with Perrier Vittel (Private bottler of mineral water, Smith *et al.* 2006). Considering the National Climate Change Response Strategy, the value of a project like this, can be highlighted in looking at the broad strategies South Africa will use to address adaptation to climate change in the different sectors such as agriculture, tourism and nature conservation.

The basic assumption for a PES project is that the alien invasive plants in the upper catchment areas of a basin, extract water at a rate above that which is associated with the natural functioning of the pristine ecosystem. This means that the farmers relying on ground and surface water at the lower parts of the catchment or river system lose a certain amount of water with the presence of the invasive species.

The project would entail upstream farmers being paid by downstream farmers to clear invasive species from their land. The payment would have to equate to the benefit of the renewed water source. In this way, the cost offsets the benefit and an efficient solution is reached whereby the ecosystem functions naturally and provides more water than before. There are also fire-related benefits involved. The same system would apply to public-owned land. Payments do not have to be in monetary form. Labour exchange is a good example of alternative forms of payment. In order to pilot this example in the Garden Route, the project cycle process (Steps 1–6) can be applied.

Step 1: A variety of factors or criteria can be used during this screening phase for the Garden Route, for example cost-effectiveness, ease of implementation and acceptability to local farmers, timeframe, and the size of beneficiaries group. A cathment area in the Garden Route should be identified through research and farmers in the indentified area should be commited to take part in this project. Farmers should be informed and all vulnerabilities identified should be noted.

Step 2: The purpose of Step 2 is to identify options for modifying the project in response to the vulnerabilities identified in Step 1. During this step, one should determine the types of stakeholders who should become involved in the analysis, review and decision-making process. For example, PES is an agricultural and water-related project. Stakeholders might include local farmers, government ministries and extension services, as well as municipal officials. The chosen local stakeholders should have a keen interest in the project under consideration, as well as how it will affect their livelihoods. During this phase, it should also be determined as to who has the valuable expertise in this project area.

Step 3: The purpose of this step is for the implementing farmers in the Garden Route, stakeholders such as the George and Eden Municipalities and specialists to evaluate each of the adaptation options included on the final list in Step 2.

Step 4: The purpose of this step is to use the results from Step 3 to select one or more adaptations measures to be implemented, with assistance from the PES project. This could possibly entail different irrigation methods for the dairy farmers in the identified catchment area, or cultivars where there is a form of subsidy from the PES project.

Step 5: The purpose of this step is to implement the project and adaptations in the selected areas of the Garden Route. A strategy should be designed that describes actions and a timeline for formalising the adaptation options, initiating activities, designing investments, and co-ordinating activities with other possible projects and programmes in the Garden Route – together with other possible donors and/or Government.

Step 6: After adaptation options have been implemented, the final step is to evaluate them. The purpose of the evaluation is to determine whether the proposed project (PES) delivers the intended benefits, and/or causes adverse outcomes.

Stakeholder buy-in at all levels is essential for funding. This can ensure that the appropriate climate change and agricultural projects or initiatives in the Garden Route, are put into effect. Yet it is important to note that the primary hypothesis of this study (Chapter 4) is that farmers adapt to perceived climate change and variability. It is important to note that results obtained indicated that not all farmers who perceived climate change, responded with adaptation methods. Understanding farmers' likely adaptive responses to anticipated climate change and for example implementing a PES project might pose a challenge to the agricultural sector of the Garden Route. However, the ability of farmers to cope with current climate variability is an important indicator of their capacity to adapt to future climate change and adaptation measures and projects. Perhaps with all the challenges and moral issues that farmers face in this region with regards to water availability, they might welcome a project that shifts the focus to wiser use of resources through a project that encourage adaptive behaviour. This should entail developing a personal awareness of behaviour that takes sustainability into account without compromising the natural resources of the Garden Route region.

To conclude this study, I will turn in my final chapter to a consideration of Stephen Gardiner's thesis that climate change creates the conditions for a perfect moral storm consisting of what he (Gardiner) refers to as moral corruption.

CHAPTER 7: **MORAL STORM**

According to Christie *et al.* (2010) the analysis and understanding of the social, behavioural and ethical dimensions of climate change are at an early stage still. Work on the social and behavioural aspects of environmental action indicates that changes in individual attitudes, values and behaviour are constrained by wider social and economic norms, structures, incentives and perceptions. In general the two human responses to climate change are, firstly to perceive climate change, and then, secondly, to adapt accordingly where adaptation refers to adjustments in human and natural systems that reduce vulnerability to climate stresses. In this study the primary hypothesis regarding the farmers of the Garden Route is that farmers adapt to perceived climate change and variability as outlined in Chapter 5. Furthermore this study has shown through the investigation of the perception that farmers have with reference to climate change, their adaptive behaviour, possible future scenarios and the input from various specialists that farmers in the Garden Route are faced with various ethical challenges on a daily basis.

In contrast to literature, which characterises ethical challenges in terms of philosophical debates about soil conservation, water use and adaptation methods, for instance, this research found that farmers perceive ethical challenges in behavioural terms. This study attempted to understand what ethical challenges farmers believe to be important. "None of us can avoid being interested in food. Our very existence depends on the supply of safe, nutritious foods. It is then hardly surprising that food has become the focus of a wide range of ethical concerns*"* (Agius *et al.*, 2008). The ecosystems surrounding people are the lifeblood of the planet, providing us with everything from the water one drinks to the food one eats and the fibre used for clothing, paper or lumber. Because of growing concerns over food safety and security, it is imperative to acknowledge the perspectives of farmers with respect to agricultural ethics.

Furthermore, vulnerability to the impacts of climate change in this area is a function of exposure to climate variables, sensitivity to those variables, and the adaptive capacity of the farming community. One of the practical issues relating to vulnerability experienced by the farmers in the Garden Route is that farmers would like the DWAF to grant them permission to increase the storage capacity of their dams. They are uncertain of what the future holds with regards to rainfall events and are feeling vulnerable. Due to the fact that farmers cannot obtain these rights so easily to build additional dams or increase their storage, as discussed in Chapter 6, certain questions remains unanswered such as: Would the lack of water storage lead to more unlawful practices, such as planting crops in floodplains, building weirs in channels and illegal pumping from rivers? What are the risks and vulnerabilities involved? Various opinions from specialists indicated that the full impacts of current and future storage structures on natural ecosystems, particularly in the already stressed rivers and estuaries (the most recent *State of the Environment Report for the Western Cape* (DEADP, 2010) states that at least 95 per cent of rivers in the Western Cape are in an endangered or critically endangered state) are still unknown.

On the other hand, farmers indicated their frustration and struggle to farm effectively in practice. The main problem is that when a farmer captures water in limited storage capacity during heavy rainfall, the excess water cannot be captured and flows straight into the sea. One can argue that if farmers were allowed to build as many dams as they wanted, focusing only on the present, the long-term effects of these actions on the environment would not be taken seriously into account as humans are the main area of concern.

According to Coward (2005), an ethical analysis according to a human-centred approach tends to favour decisions and actions that are best for humans, and this entails an avoidance of climate change – it does not foster change of mentality or practice while climate change continues. Some farmers argued that building more dams is based on the ground of being able to produce the same amount, because production, processing, storage and distribution of food and agricultural products are generally accepted as routine parts of everyday life all around the world.

Therefore, these activities have rarely been addressed within the realm of ethics. Surely one can argue that food, agriculture, and the economic benefits derived from taking part in the associated system, are a means to an end: On the one hand, feeding the population and on the other hand, preserving the earth's food-producing capacity and natural ecosystems for future generations. The analyses, according to the four scenarios (Chapter 6), indicated the possible future trends using specific climate variables, together with possible adaptation strategies. With no change in climatic conditions, but a change in farming practices towards environmental protection, the farming sector may achieve sustainability. However, if climatic conditions should change significantly in the future, current changes in farming practices may be insufficient to guarantee its sustainability. With stricter water limitations and without access to financial solutions, it appears that these farmers may soon reach the limits of their adaptive capacity.

Most of the farmers have managed to maintain their livelihoods by continuing to produce, however, the study found that, in order to adequately address the dynamic challenges of climate change, interventions at various levels are necessary. Anticipating climatic variability and change by incorporating resilience into development assistance, will lead to more sound and sustainable agriculture that will better serve the Garden Route region (Scenario 4). In order to reach a form of sustainable agriculture, farmers indicated that they face many ethical challenges.

Philosophers, agriculturalists, and academics who write about ethical issues in agriculture often focus on the philosophical debates, such as sustainability, and the proper use of the environment[17]. An important question is whether farmers are also concerned about these issues specifically, or "philosophical" issues generally. Farmers who were interviewed not only expressed concerns about the "debates", but they also expressed concerns about ethics from a behavioural perspective – doing what they believe to be right.

Farmers indicated that the Garden Route region is a prominent dairy and vegetable-producing area. Vegetables and pastures are extensively irrigated, with perennial ryegrass, kikuyu and lucerne as the pasture base of the dairy industry. Temperatures dictate the time of the year when different pastures produce their best. However, it is not necessarily easy to indicate which crops would adapt better to hotter and drier conditions. Farmers indicated that there is a great need for research. Currently, farmers are taking the initiative and the risks to see what works, and what does not work. Farmers also indicated that they have started looking at different geographical areas. Farmers could split the risk and move their farms geographically. But it is economically detrimental to fall into a backward spiral. Farmers need to adapt, but not think of disinvesting in the area. One farmer indicated that he is already in the process of moving his stock (cows) to the northern parts of the country, in agreement with another farmer, who is already farming there. Farmers' frustrations are evident; they also foresee that in the next ten years, the legislation on water issues will not change. To quote a farmer interviewed: *"One has to be open and see that this is a reality that probably would not change. One needs to adapt and consider what the options are."* Most farmers, but particularly the older ones who reminisced about what farming was like in the past, lamented the fact that farming is becoming more like a business and less like a way of life.

Due to the fact that farmers are feeling increasing economic pressures to compete to make a living, many farmers acknowledged a pressure to take "short cuts" that they otherwise would not have been willing to consider. However, none of the farmers interviewed specifically

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[17] Benhin, (2006); Chrispeels and Mandoli, (2003); Gbetibouo, (2009); Maddison, (2006); Schultze, (2003); Smit and Pilifosova (2003).

admitted to doing anything seriously unethical. Indeed, many professed strongly the belief that most farmers are very ethical people and that it is important to do the right thing. The ethical challenges facing farmers, as expressed by them, reflected the idea that climate change creates pressures for them that challenge their desire to do what is right as opposed to do what they feel they must do in order to survive. Farmers who tire of running faster just to stay in the same place begin to look for alternatives to running – that is, they may seek unethical short cuts. Identifying the specific margins at which farmers take these ethical short cuts and how they perceive these in terms of overall ethical problems in agriculture is an important step in identifying and resolving important ethical problems in agriculture and addressing the challenge of Scenario 4 (anticipating climate variability and change).

In his recent article "A perfect moral storm: Climate change, intergenerational ethics and the problem of moral corruption" (2006) and in his most recent book *A perfect moral storm, The ethical tragedy of climate change* (2011), Stephen Gardiner shows that the complexity of climate change contributes to the underestimation of its moral significance. To illustrate the difficulties of the ethical duties and challenges raised by climate change, Gardiner uses the image of a "perfect moral storm."

He distinguishes between three different characteristics of climate change that, in interaction with one another, constitute three different moral storms that, while they are very dangerous in themselves, become extremely destructive in that they tend to overlap and intersect, threatening our ability to recognize and respond to the ethical challenges of climate change.[18] The first characteristic that leads to what Gardiner refers to as *the global storm* (2011: 24-32), is the *dispersion of the causes and effects* of climate change. He describes this in saying that a vast number of individuals and institutions contribute to the causes of climate change, but that the impacts of greenhouse gas emissions are often not experienced solely or even primarily at the numerous source points of the emissions, but rather at places (and even times) far removed from these source points. For Gardiner, this spatial dispersion of causes and effects constitutes the "epicentre" of climate change as a global storm: people all around the globe experience the effects of climate change, whether they contributed to it or not, while those causing climate change are mostly the least affected by it, and behave as if their emissions are not dangerous in any way at all.

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[18] Here Gardiner draws on the true story of the "*perfect storm",* as described in the book by Sebastian Junger (1997). In this book, and also in the film that was made of it, the perfect storm was brought about by a three stage evolving storm that created a superstorm that led to the sinking of the fishing vessel *Andrea Gail*.

The *fragmentation of agency* is a second characteristic of climate change that Gardiner highlights, linking it strongly with the dispersion of causes and effects referred to above, as well as *institutional inadequacy*. Gardiner describes the fragmentation of agency not only with reference to global institutions that might coordinate an effective response to climate change, but fails dismally in doing so (since they emphasize their own interests instead of the interests of the whole of humanity and the community of life), but also in terms of one generation that (still) may be able to act to prevent dangerous climate change in the future, but does not do so – also for selfish reasons, with the added benefit that future generations will not be able to hold them accountable in a distant future for the unwillingess to really address climate change. He mentions that this international situation is often understood as a "prisoner's dilemma" or a "tragedy of the commons" where a situation arises with two facets where firstly it is collectively rational to cooperate and restrict overall emissions, and secondly where it is individually rational not to restrict one's own emissions. Gardiner highlights that climate change cannot be seen as a normal tragedy of the commons due to various difficulties such as the precise magnitude and global distribution of effects, and factors such as the different infrastructures of current civilizations.

Gardiner (2011: 32-40) refers to the second dimension of the moral storm of climate change as the *intergenerational storm*. This arises from a temporal perspective on the dispersion of causes and effects, fragmentation of agency, and institutional inadequacy. The temporal perspective highlights that the effects of climate change are time lagged, which creates difficulties in grasping the connection between causes and effects. Gardiner mentions further that by the time serious impacts occur, people will already be committed to much more change, complicating the ability of standard institutions and conventional approaches to deal with the problem. Another, even more troubling, implication is that the full effects of current actions will not be realized until far into the future. Therefore the current generation is in effect passing the costs of their behavior on to future generations, without feeling any guilt in passing the buck in this manner.

The third dimension of the perfect moral storm that Gardiner highlights (2011: 41-44), is that of *theoretical ineptitude*. In this context he draws attention to theoretical tools such as Cost-Benefit-Analysis and the anthropocentric bias in our thinkining – and to this one can add conventional Financial Discounting and conventional Rational Choice Theory – that are all used to determine whether it is feasible to address problems in the present that may affect us in future. While these tools may help us to determine under normal circumstances whether it is worth our while to make an investment in the present that promises to yield future dividends, Gardiner's argument is that the uncertainties and complexities of climate change actually renders these conventional tools inadequate. On the other hand, he argues, if we continue to use them in the context of climate change to determine levels of investment in mitigation or adaptation measures, they will only place us in the position of self-deception – making it impossible, or very difficult for us to take action in the present to prevent the disastrous effects of dangerous climate change in the future. In fact, these conventional theoretical tools will rather provide us with "rational" arguments to do nothing regarding climate change.

In terms of Gardiner's metaphor, the overlap of climate change as a global storm, as an intergenerational storm, and as a storm of theoretical ineptitude creates the perfect moral storm of moral corruption. Within this context Gardiner (2011: 45-48) has in mind denial, complacency, selective attention and unreasonable doubt regarding climate change. As he sees it, the three fundamental characteristics of climate change create a real danger of self-deception, and in particular of remaining satisfied with policies that, on the surface, appear to take the issue of climate change seriously, but actually do little to address the concerns. He thus describes climate change as a perfect moral storm in that it brings together global, intergenerational and theoretical issues that undermine our ability to recognize and respond appropriately to the ethical challenges posed by climate change.

This image of climate change as a perfect moral storm allows Gardiner then to examine the problem in separate but yet related dimensions. With Gardiner's image in mind I now would like to make a few closing remarks about the range of ethical challenges relating to climate change that were explored in this study. Perhaps the main conclusion that one can defend, is that climate change is a major risk multiplier because it systematically worsens and intensifies all other problems. In such a context with all of its uncertainties and complexities, moral corruption constitutes a significant threat because it permits self-deception by selectively applying our attention to components of climate change that ease our moral burden. From the results of the study, it is evident that some of the farmers in the Eden District, fell victim to this moral corruption – even if they did not do so self-consciously and deliberately. They did so by focussing all, or almost all of their attention, as one can understand, on (economic) survival in the face of climate change, reverting to numerous short term measures that they believed would extend their economic viability. In this however, they experienced no qualms in taking ethical shortcuts, or adopting measures that actually could increase their ecological unsustainability, thereby increasing their vulnerability to climate change, and thus undermining their ability for effective long term adaptation.

This point can also be made in another, perhaps more positive manner. In addition to working on tangible enforceable policies with regards to climate change, and educating all the stakeholders (farmers, public etc.) about it, one should also evolve a personal social consciousness to be equipped to deal fairly and ethically with a changing world. In general the belief is that people will naturally be better off in the future because of continued economic growth and technological innovation – i.e. extrapolating the present into the future. Yet, the loss of a very important ecological good, like climate stability, may overwhelm any economic or technological gains that we may think we have achieved in the present. We cannot escape the possibility that the effects of climate change may undermine the very frameworks that have been successful in recent history. From the results of the study it is evident that many farmers in the Eden District are victims of not being able to take this insight on board.

Recommendations to evolve a personal social consciousness is to first realize that moral corruption appears *de facto* in the self-interested choice of strategies we select in responding to climate change. By emphasizing the self-interested strategies for collective action suggested by the global efforts to address the effects of climate change, and by promoting the translation of these global efforts in strategies of self-interested action in local contexts, the moral corruption sketched above appears only to be exacerbated and perpetuated. The second recommendation is therefore this: strategies designed to address climate change, whether in the global or local context, should be evaluated in terms of (at least) three fundamental questions: 1. Do these policies really take into account, make visible and recognize the complexities of the causes and effects of climate change as they exist and unfold in global, geographical and inter-generational, temporal terms? 2. Do these policies really help us to articulate in concrete terms what our obligations with regards to mitigation and adaptation are today towards those living in generations coming after us? 3. Do these policies merely extrapolate conventional theoretical frameworks regarding economic growth, or do they help us to think in fresh terms about changed circumstances? Again, my conclusion is that the majority of farmers in the Eden District, if not all, are still a far way off from critically examining the policies that they themselves have chosen to respond to the effects of climate change – if they acknowledge the reality of climate change and choose to respond to it at all.

Without evaluating the strategies we propose to address climate change along these lines, I am afraid that we will not be able to move beyond contemporary self-interested preferences. In contrast to the practical effects of moral corruption, and appealing to an important distinction that should be made between the interests of self and concern for the other, I strongly argue for a critical position in which we question the manner in which we constitute the distinction between individual and collective interests so that individual interests always win. I rather argue for an approach in which concern for the other, whether this other is conceptualized in ecological terms or in terms of future generations, stands central. That leaves us with the challenge within the context of the perfect moral storm to decide and articulate in concrete terms, what it will entail to recognize, acknowledge, confront and overcome the moral corruption that climate change can lead us into in the practice of agriculture. Formulated in positive terms: our challenge in the face of climate change is to gain knowledge and insights, and develop intellectual tools that can move us beyond merely extrapolating the present into the future, and empower us to do what would really be ethically right in the practice of agriculture.

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ANNEXURES

ANNEXURE A: FINAL QUESTIONNAIRE

The study examines how farmers' perceptions of weather conditions correspond with climatic data recorded at meteorological stations in the Garden Route. The study also analyses farmers' adaptive responses to, and perception of climate change: Are farmers' perceptions and adaptation measures in line with climatic data records, as well as with predicted Western Cape climate changes?

Wessa study	
Master study	

1. <u>Information about farm</u>

1.1	Municipality of :	
1.2	Farmers' Association:	
1.3	Water Management Association:	
1.4	Are you the owner of the farm?	
1.5	Type of farming (e.g. crop types, diary):	
1.6	Do you have access to water (e.g. dam, river and boreholes) for irrigation purposes?	

1.7	Current water quota:	
1.8	Area (ha) irrigation:	
1.9	Area (ha) dry land:	

2. Biographical information and perception of climate change:

2.1 Gender:

Male	
Female	

2.2.1 How many years of farming experience do you have?

0–10 years	
10–20	
20–30	
40–50+	

2.2.2 What is your highest formal qualification?

Grade 11 (Standard 9) or less	
Grade 12 (Standard 10 / matric)	
First university degree	
Post Graduate university degree: Honours, Masters, PhD or DPhil	
First technikon degree / National Diploma / National Higher Diploma	
Advanced technikon degree	
Other (Please specify)	

2.3 Climate

2.3.1 How often do you make use of any of the following to obtain information about the weather forecast?

	OFTEN (weekly)	SELDOM (monthly)	NEVER
2.3.1.1 Television			
2.3.1.2 Radio			
2.3.1.3 Internet			
2.3.1.4 Newspaper			
2.3.1.5 Other (Please specify)			

	YES	NO
2.3.2 Have you, in the past, obtained any information / advice on climate change and on measurements to adapt to it?		
2.3.3 Do you, in any way, rely on meteorological information (wind, temperature, rainfall, air pressure and fronts) in conducting farming activities?		

2.4 Indicate where you find such information:

	YES	NO
2.4.1 National weather bureau (SA Weather Bureau)		
2.4.2 Regional meteorological service		
2.4.3 Local, private meteorological services		
2.4.4 Media (Television and newspaper)		
2.4.5 Other (Please specify)		

2.4.6 Do you believe that an improvement of weather forecast services would benefit the following aspects pertaining to farming?

	YES	NO
2.4.6.1 Fungicide treatment		
2.4.6.2 Insect control		
2.4.6.3 Weed killer treatment		
2.4.6.4 Irrigation		

2.5 Irrigation

	YES	NO
2.5.1 Would you consider the choice of an irrigation system as a strategy to adapt to climate change?		
2.5.2 Do you currently make use of any available irrigation advice?		

2.5.3 What kind of irrigation system do you use?

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3. Observation of conditional changes and adaptation

In this section, please indicate to what extent you have experienced the changes under question, and how you have adapted to the resulting conditions.

3.1 Observation of changes (diverse changes):

	Large extent (75% +)	**Some extent (50%+)**	**Little extent (25%+)**	**Not at all (0%+)**
3.1.1 Have you, during the years, observed a reduction in crop yields?				
3.1.2 Have you, during the years, observed an increase in the incidences of pests?				

3.1.3 Have you, during the years (farming experience), observed an increase in the incidence of diseases?				
3.1.4 Have you, during the years, experienced a change in the availability of water on your farm, due to climatic factors?				
3.1.5 Have you, during the years, experienced a change in the availability of water on your farm due to a change in the water quota?				
3.1.6 Have you, during the years, experienced a reduction in soil fertility (dry land, not irrigated area) due to change in rainfall?				

3. 2 Observation of temperature changes

	INCREASE	**DECREASE**	**NONE**
3.2.1 Have you, during the years, observed a change in **maximum** temperature? 3.2.2 Indicate the section of time in which you have made the observation: 1960–1969 | 1970–1979 | 1980–1989 | 1990–1999 | 2000+ 3.2.3 Indicate the month(s) in which you made the observation: JAN | FEB | MAR | APR | MAY | JUN JUL | AUG | SEP | OCT | NOV | DEC			

3.2.4 Have you, in recent years (last 5), observed a change in **minimum** temperatures? 3.2.5 Indicate the period of time in which you have made the observation: 1960–1969 | 1970–1979 | 1980–1989 | 1990–1999 | 2000+ 3.2.6 Indicate the month(s) in which you made the observation: JAN | FEB | MAR | APR | MAY | JUN JUL | AUG | SEP | OCT | NOV | DEC			
3.2.7 Has there, during the years (farming experience), been an increase, decrease or no change in the number of **very hot** days? 3.2.8 Indicate the period of time in which you have made the observation: 1960–1969 | 1970–1979 | 1980–1989 | 1990–1999 | 2000+ 3.2.9 Indicate the month(s) in which you made the observation: JAN | FEB | MAR | APR | MAY | JUN JUL | AUG | SEP | OCT | NOV | DEC			

3.3 Views on temperature change:

3.3.1 Do you regard the change in **temperature** a factor to consider when planning future agricultural practices? Please explain.

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3.3.2 In what way do you perceive that the **maximum and minimum** temperatures will change in the future (next 30 years)?

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4. Observation of changes in rainfall:

	INCREASE	DECREASE	NONE
4.1.1 Have you, during the years, observed an increase, decrease or no change in the status of rainfall? 4.1.2 Indicate the period of time in which you have made the observation: 1960–1969 | 1970–1979 | 1980–1989 | 1990–1999 | 2000+ 4.1.3 Indicate the month(s) in which you made the observation: JAN | FEB | MAR | APR | MAY | JUN JUL | AUG | SEP | OCT | NOV | DEC			

	YES	NO
4.2 Do you consider the distribution of rainfall to have become erratic in recent years?		
4.3 Have you, in recent years, experienced any improvement in the distribution of rainfall?		

4.4 Views on changes in rainfall:

4.4.1 How do you foresee rainfall patterns to change in future (the next 30 years)?

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4.4.2 Do you regard the change in **rainfall** a factor to consider when planning future agricultural practices? Please explain.

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5. Observation of extreme events (floods, fire, droughts and wind)

	INCREASE	DECREASE	NONE
5.1 Have you, during the years, observed an increase, decrease or no change in flood events?			
5.2 Have you, during the years, observed an increase, decrease or no change in fires?			
5.3 Have you, during the years, observed an increase, decrease or no change in recurrent droughts?			
5.4 Have you, during the years, observed an increase, decrease or no change in extreme wind conditions?			

	YES	NO
5.5 Do you have any insurance policy that covers the risk of a contingent loss caused by any extreme event?		

5.6 Views on extreme events:

5.6.1 How do you foresee extreme weather events to change in future (next 30 years)?

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5.6.2 Is the possible increase of extreme weather events a factor you consider with regards to future planning for your agricultural practices? Why?

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6. Adaptation (based on experience: temperature, rainfall, extreme events and types of farming).

	YES	NO
6.1 Have you made any adjustments in your farming activities according to your long-term perception and experience of temperature, rainfall and extreme events?		

6.2 If you did make changes, what encouraged you to do so (such as advice from agricultural experts, own observation or experience, weather conditions, etc.)? Please explain.

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6.3 What were (or still are) the main constraints in changing your ways of farming?

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7. <u>Adaptation and future considerations</u>

7.1 Which of the following measures – as a result of climate change:

- would you consider in future?
- have you already implemented and when?

If you have already implemented any other measure not mentioned, please state them under 7.1.20 below.

	Consider in future	**Implemented when (year)**	**None**
7.1.1. Change crop variety.			
7.1.2. Automated irrigation.			
7.1.3. Implement soil conservation techniques.			
7.1.4. Buy insurance or insure your farm.			
7.1.5. Reduce number of livestock.			
7.1.6. Lease your land.			
7.1.7. Find off-farm job.			
7.1.8. Build a water-harvesting facility.			
7.1.9. Change amount of arable land.			
7.1.10 Change planting date.			
7.1.11 Livestock feed supplements from off-farm.			

7.1.12 Resort to more heat-tolerant breeds rather than traditional ones.			
7.1.13 Change the timing, duration and location of grazing.			
7.1.14 Increase application of chemicals (such as Erian) to slow down evapo-transpiration.			
7.1.15 Apply more organic fertilization to retain moisture content and fertility of soil.			
7.1.16 Keep the crop residues of the previous harvest on the land to preserve soil moisture, cool the soil surface and stabilise soil temperature.			
7.1.17 Sink your own borehole(s).			
7.1.18 Make use of a floodplain for agricultural production.			
7.1.19 Use credit to buy new technology.			
7.1.20 Other			
7.1.21 No adaptation			

8. Utilisation of rivers

8.1 Was it necessary for you to do any of the following in the recent years?

	YES	NO
8.1 Did you need to influence the course of the river by means of berms or otherwise in order to protect your crops against floods?		
8.2 Have you been advised to remove silt from the river after flood events?		

8.3 A quest for solutions (river utilisation)

	YES	NO
8.3.1 Does the change in climate contribute to the fact that you farm on the flood-plain?		

8.3.2 Have you considered **organic** farming? What is in your opinion constraints in this regard?

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8.3.3 Have you considered **conservation** farming? What, in your opinion, are the constraints in this regard?

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9. Soil and water conditions on farms

9.1 Please indicate, to what extent you agree, that the following conditions (with regard to soil and water) are present on your farm.

		AGREE	**NEUTRAL**	**DISAGREE**
9.1.1	The soil consists of sand and clay (duplex) and has a low degree of aggregation.			
9.1.2	There is an increase in root disease and nematodes.			
9.1.3	The occurrence of algae in water has increased.			
9.1.4	There is less surface water and groundwater recharge.			

9.2 A quest for solutions (water and soil)

Please indicate, to what extent you agree, to the following possible solutions (with regard to soil and water) on your farm.

	AGREE	NEUTRAL	DISAGREE
9.2.1 Integrated water resource planning should form part of daily practice (e.g. investigate water re-use and the integration of resources such as groundwater, surface water and rainwater capture).			
9.2.2 An advisor should form part of a management team on a farm.			
9.2.3 Realistic setback lines should be determined for agricultural practices around rivers, floodplains and wetlands.			
9.2.4 Artificial wetlands should be created to protect floodplains.			
9.2.5 Revise water allocations (quotas) for farms.			

9.2.6 In your opinion, what are the main constraints with regard to the eradication of alien plants on your farm?

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9.2.7 Please rate the effectiveness of the following measures on your farm.

	HIGHLY EFFECTIVE	EFFECTIVE	INEFFECTIVE	HIGHLY INEFFECTIVE	NOT APPLICABLE
9.3.1 Replace chemical fertilisers with compost, humus, worms and natural minerals.					
9.3.2 Store surplus water (e.g. earth dams and rain tanks on buildings).					

9.3.3 Re-direct water run-off (to canals and ponds), and recycle water (grey water from houses, factories, etc.).					
9.3.4 Remove invasive alien plants and other organisms, and restore natural habitat.					
9.3.5 Replace old diesel engines.					
9.3.6 Change to renewable energy (wind power and solar power).					
9.3.7 Workshops and farmer mentoring.					

10. <u>Official structures of support</u>

10.1 Do you think any of the following role-players can make a difference with regard to problems experienced due to climate change?

	YES	**NO**
Department of Agriculture		
Department of Water Affairs		
Department of Environmental Affairs and Development Planning		
District Municipality		
CapeNature		
Farmers' Association		
Water Management Association		
Weather Bureau		

10.2 Indicate possible changes you would like to see with regard to the following role-players:

Department of Agriculture:
Department of Water Affairs:
Department of Environmental Affairs and Development Planning:
District Municipality:
CapeNature:
Farmers' Association:

Water Management Association:
Weather Bureau:
Financial support:
Other:

10.3 Any other comments?

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THANK YOU FOR YOUR TIME!

ANNEXURE B: ETHICAL CLEARANCE (US) AND CONSENT LETTER (WESSA)

UNIVERSITEIT•STELLENBOSCH•UNIVERSITY
jou kennisvennoot • your knowledge partner

12 November 2009

Tel.: 021 - 808-4622
Enquiries: Sidney Engelbrecht
Email: sidney@sun.ac.za

Reference No. 255/2009

Ms C Steyn
Department of Philosophy
University of Stellenbosch
STELLENBOSCH
7602

Ms C Steyn

APPLICATION FOR ETHICAL CLEARANCE

With regards to your application, I would like to inform you that the project, *Die persepsie en aanpassingsmetodes van boere in die Tuinroete ten opsigte van klimaatsverandering: `n omgewingsetiese persepsie* has been approved on condition that:

1. The researcher/s remain within the procedures and protocols indicated in the proposal;
2. The researcher/s stay within the boundaries of applicable national legislation, institutional guidelines, and applicable standards of scientific rigor that are followed within this field of study and that
3. Any substantive changes to this research project should be brought to the attention of the Ethics Committee with a view to obtain ethical clearance for it.

We wish you success with your research activities.

Best regards

MRS. MALÉNE FOUCHÉ
Manager: Research Support

Afdeling Navorsingsontwikkeling • Division of Research Development
Privaat Sak/Private Bag X1 • 7602 Stellenbosch • Suid-Afrika/South Africa
Tel +27 21 808 9111 • Faks/Fax: +27 21 808 4537

WESSA

CONSENT TO PARTICIPATE IN RESEARCH

Research theme:

The perception and adaptation methods of farmers in the Garden Route to climate change: An evaluation of responses in correspondence with climate data recorded at meteorological stations in the Garden Route and predicted climate change for the Western Cape.

You are asked to participate in a research study conducted by WESSA under the supervision of Dr S du Toit (Head of Conservation, Western Cape, WESSA). Ms C Steyn will conduct the survey. The results will be contributing to a report for Eden District Municipality. You were selected as a possible participant in this study because you are part of the agricultural sector in the Garden Route as an active farmer.

1. PURPOSE OF THE STUDY

The study examines how farmer perceptions correspond with climate data recorded at meteorological stations in the Garden Route, and analyzes farmers' adaptation responses and perception to climate change. The aim of the analysis of the questionnaire is to determine whether farmers' perceptions and adaption measures are in line with the climatic data records and predicted Western Cape climate change. The aim of this project is to identify and promote logical, financially feasible alternatives that will encourage wise, sustainable use of land and water resources within the agricultural sector of the Garden Route.

2. PROCEDURES

WESSA
PEOPLE CARING FOR THE EARTH

Western Cape Region

George Office
31 Progress Street
George, 6529

Tel 044 874 7097
Fax 044 874 6119
steve@wessa.co.za

www.wessa.org.za

If you volunteer to participate in this study, we would ask you to do the following things:

1) Indicate in the block (mark with x) on the first page of the questionnaire that you are willing to participate voluntarily in this research.
2) To complete a questionnaire that would take up approximately 1 hour of your time.

The completion of the questionnaire will only take place once in the presence of yourself and the investigator at your farm, or a place that was agreed on between yourself and the investigator.

3. POTENTIAL RISKS AND DISCOMFORTS

The completion of the questionnaire does not place you under any risk or commitment.

4. POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

There will be no direct benefits for you by participating in this study, but in the long run, you may gain indirectly from a better understanding of logical, and financially feasible alternatives that will encourage wise, sustainable use of land and water resources within the agricultural sector of the Garden Route. The results of this study may also contribute to wiser and more sustainable policy options at all levels of government for the agricultural sector in the Garden Route.

5. PAYMENT FOR PARTICIPATION

Participants take part on a voluntary basis and will not receive any payment.

6. CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be guaranteed in all reports that this study leads to – which means that no information will be published that can be linked with you directly. The final report will be released to Eden District Municipality together with recommendations obtained from questionnaires.

7. PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you don't want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so.

8. IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact:

1) Dr. S du Toit (WESSA: Supervisor) Tel: (044) 874 7097 *email: steve@wessa.co.za*
2) Ms. C Steyn: (Investigator) by Tel: (044) 851 0383 *email: corlie.gardenroute@gmail.com*

9. RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject in the WESSA study, contact Dr S du Toit (WESSA), Tel: (044) 874 7097 *email: steve@wessa.co.za*

10. CONSENT

By indicating in the block (mark x) provided on questionnaire you are indicating that that you are willing to participate voluntarily and anonymously in this research study.

11. COPY OF INFORMATION SHEET

This information sheet is provided to you for any further questions and future reference .

12. AVAILABILITY OF RESULTS OF THIS STUDY

You will receive a copy of the final report (cd/hard copy). The scheduled completion date for this report is 26 March 2010.

13. PERMISSION TO DO RESEARCH FOR MASTER'S DEGREE

It is hereby confirmed that WESSA has granted formal permission to Ms. C Steyn to use the results of this study for further analysis with a view to completing a research Master's thesis. Further details about this Master's study is available from Ms. Steyn.

…………………………………………………………	……………………………………………
Dr. S. du Toit	Ms. C. Steyn
On behalf of WESSA	Researcher

ANNEXURE C: HECKMAN PROBIT ADATATION MODEL – RESULTS

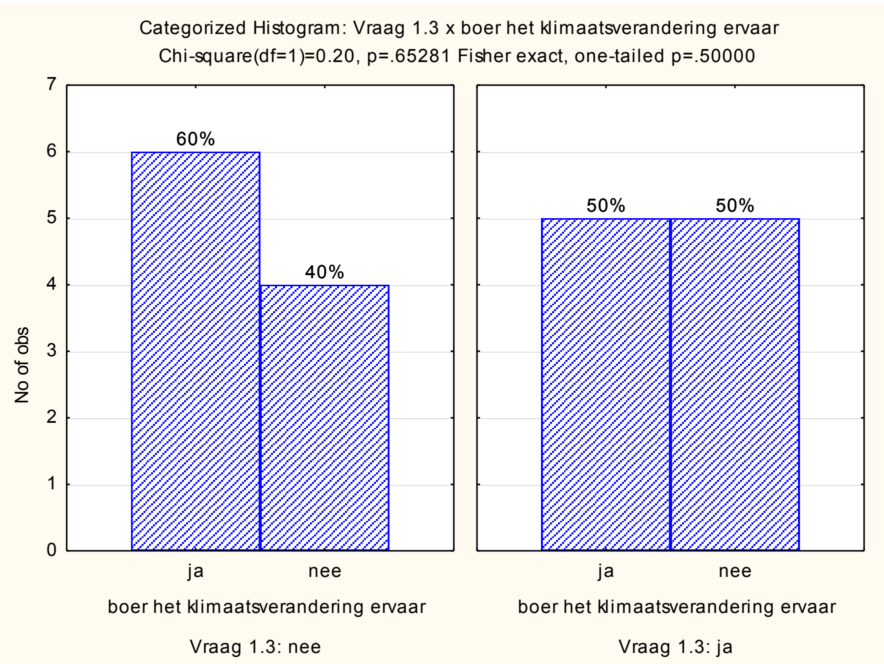
Univariate

Vraag 1.3 | boer het klimaatsverandering ervaar

2-Way Summary Table: Observed Frequencies (subset in Heckman.stw)

	Marked cells have counts > 10. Chi-square(df=1)=0		
Vraag 1.3	boer het klimaatsveranderin ervaar ja	boer het klimaatsveranderin ervaar nee	Row Totals
nee	6	4	10
Row %	60.00%	40.00%	
ja	5	5	10
Row %	50.00%	50.00%	
Totals	11	9	20

Categorized Histogram: Vraag 1.3 x boer het klimaatsverandering ervaar



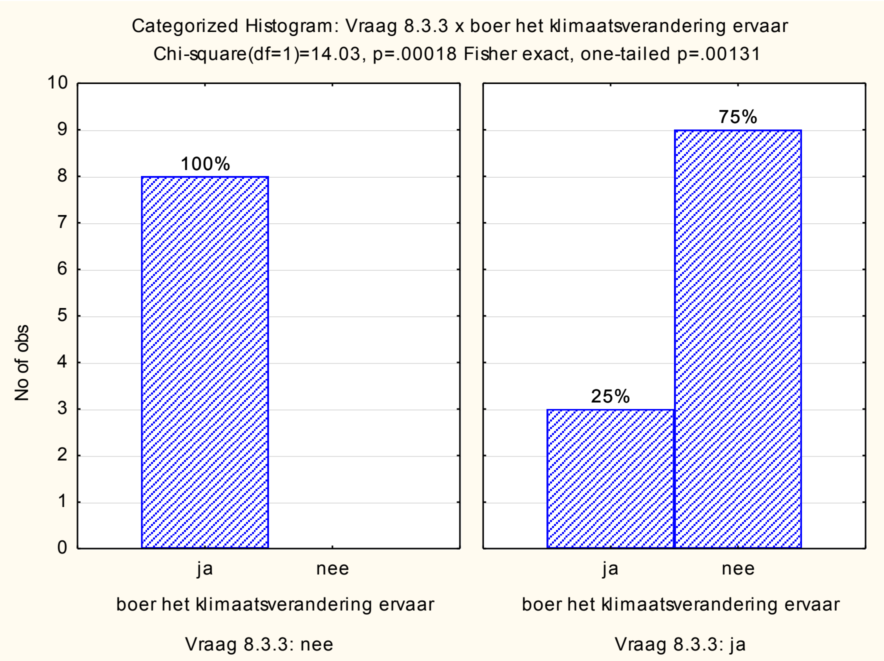
Vraag 8.3.3 | boer het klimaatsverandering ervaar

2-Way Summary Table: Observed Frequencies (subset in Heckman.stw)

Marked cells have counts > 10. Chi-square(df=1)=1

Vraag 8.3.3	boer het klimaatsveranderin ervaar ja	boer het klimaatsveranderin ervaar nee	Row Totals
nee	8	0	8
Row %	100.00%	0.00%	
ja	3	9	12
Row %	25.00%	75.00%	
Totals	11	9	20

Categorized Histogram: Vraag 8.3.3 x boer het klimaatsverandering ervaar



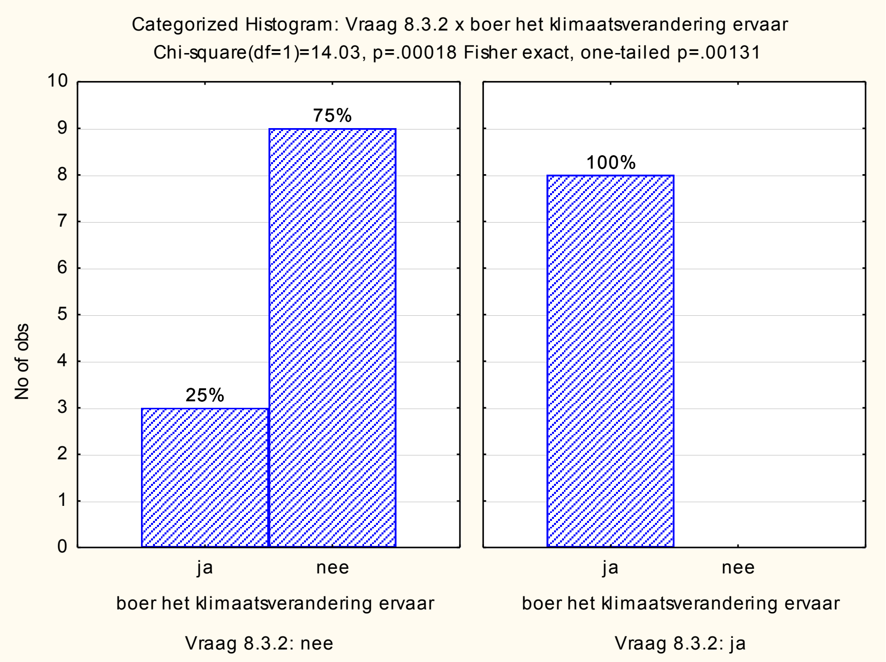
Vraag 8.3.2 | boer het klimaatsverandering ervaar

2-Way Summary Table: Observed Frequencies (subset in Heckman.stw)

Marked cells have counts > 10. Chi-square(df=1)=1

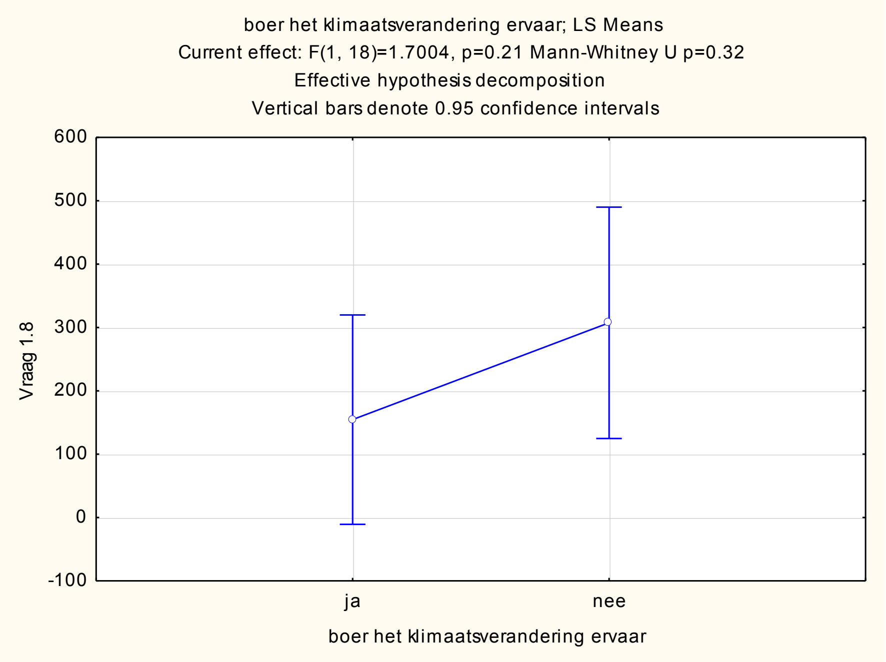
Vraag 8.3.2	boer het klimaatsveranderin ervaar ja	boer het klimaatsveranderin ervaar nee	Row Totals
nee	3	9	12
Row %	25.00%	75.00%	
ja	8	0	8
Row %	100.00%	0.00%	
Totals	11	9	20

Categorized Histogram: Vraag 8.3.2 x boer het klimaatsverandering ervaar

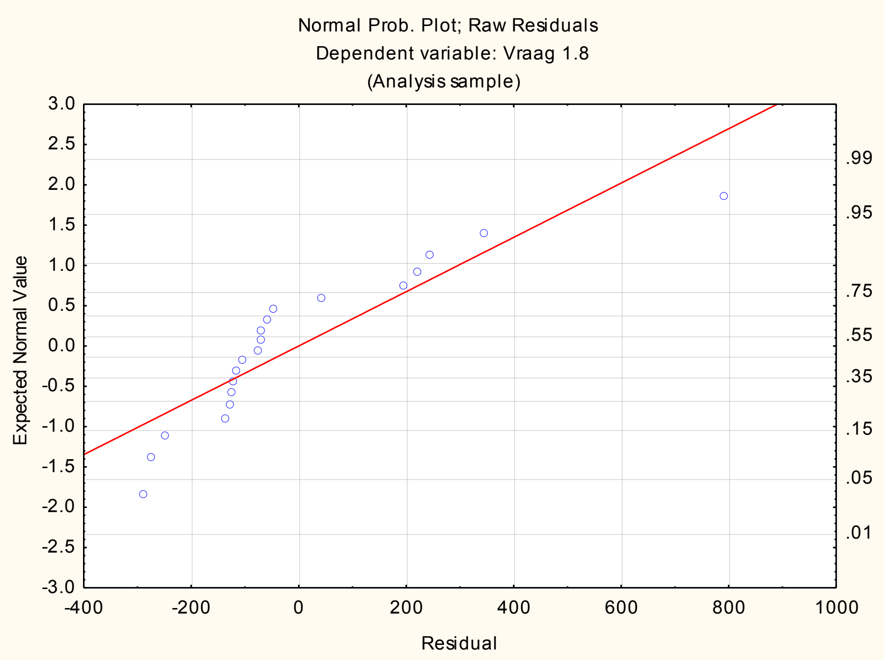


Vraag 1.8 | boer het klimaatsverandering ervaar

boer het klimaatsverandering ervaar; LS Means



Normal Prob. Plot; Raw Residuals



Tests of Homogeneity of Variances (subset in Heckman.stw)

	Tests of Homogeneity of Variances (subset in Effect: "boer het klimaatsverandering ervaar"				
	Hartley F-max	Cochran C	Bartlett Chi-Sqr.	df	p
Vraag 1.8	3.81087	0.79213	3.68023	1	0.05506

boer het klimaatsverandering ervaar; LS Means (subset in Heckman.stw)

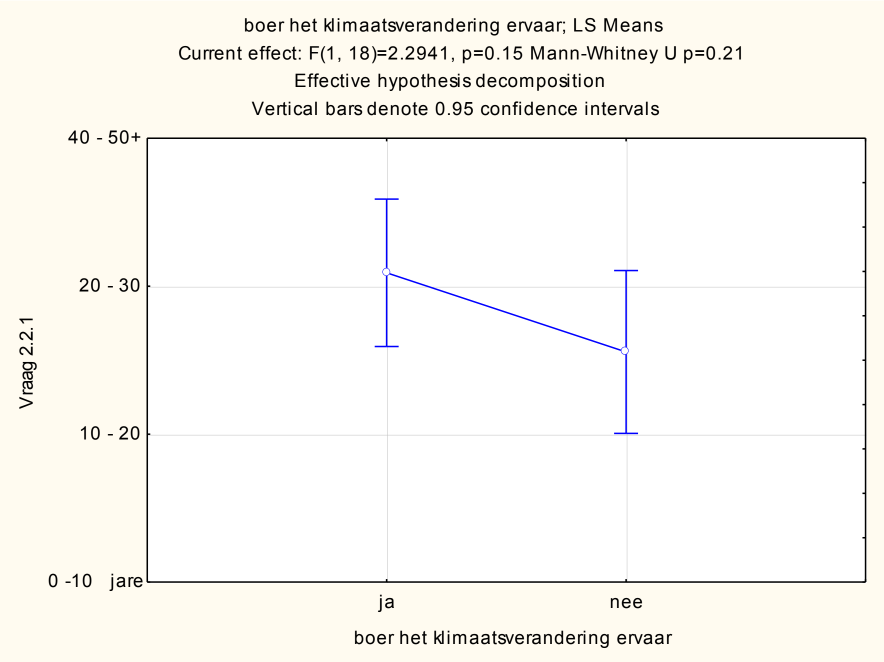
	boer het klimaatsverandering ervaar; LS Means (subset in Heckman.s Current effect: F(1, 18)=1.7004, p=.20866 Effective hypothesis decomposition					
Cell No.	boer het klimaatsveranderin ervaar	Vraag 1.8 Mean	Vraag 1.8 Std.Err.	Vraag 1.8 -95.00%	Vraag 1.8 +95.00%	N
1	ja	154.545	78.5989	-10.584	319.675	11
2	nee	307.333	86.8944	124.774	489.891	9

Descriptive Statistics (subset in Heckman.stw)

	Descriptive Statistics (subset in Heckman.stw)						
Effect	Level of Factor	N	Vraag 1.8 Mean	Vraag 1.8 Std.Dev.	Vraag 1.8 Std.Err	Vraag 1.8 -95.00%	Vraag 1.8 +95.00%
Total		20	223.300	265.444	59.355	99.0680	347.532
boer het klimaatsverandering ervaar	ja	11	154.545	173.816	52.407	37.7737	271.317
boer het klimaatsverandering ervaar	nee	9	307.333	339.315	113.105	46.5120	568.154

Vraag 2.2.1 | boer het klimaatsverandering ervaar

boer het klimaatsverandering ervaar; LS Means



boer het klimaatsverandering ervaar; LS Means (subset in Heckman.stw)

boer het klimaatsverandering ervaar; LS Means (subset in Heckman.stw)
Current effect: F(1, 18)=2.2941, p=.14723
Effective hypothesis decomposition

Cell No.	boer het klimaatsveranderin ervaar	Vraag 2.2.1 Mean	Vraag 2.2.1 Std.Err.	Vraag 2.2.1 -95.00%	Vraag 2.2.1 +95.00%	N
1	ja	3.09090	0.23710	2.59277	3.58904	11
2	nee	2.55555	0.26212	2.00484	3.10626	9

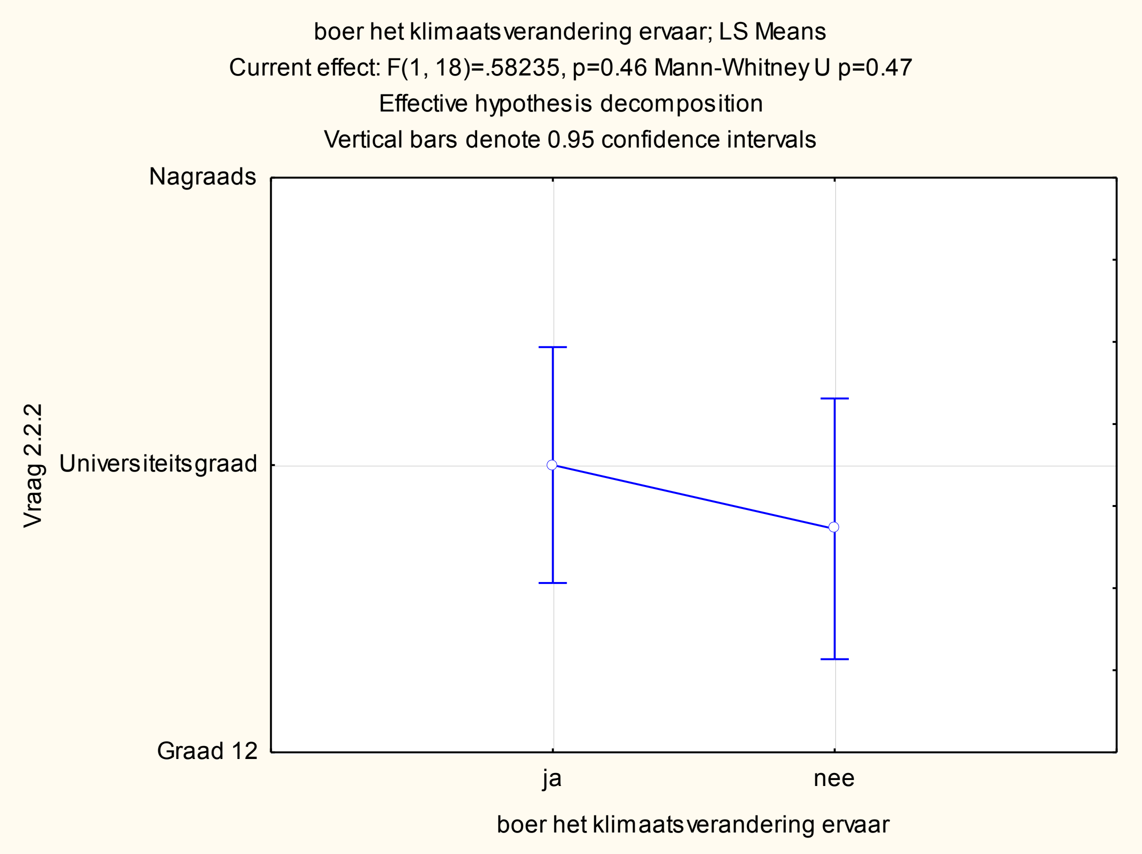
Descriptive Statistics (subset in Heckman.stw)

Descriptive Statistics (subset in Heckman.stw)

Effect	Level of Factor	N	Vraag 2.2.1 Mean	Vraag 2.2.1 Std.Dev.	Vraag 2.2.1 Std.Err	Vraag 2.2.1 -95.00%	Vraag 2.2.1 +95.00%
Total		20	2.85000	0.81272	0.18173	2.46963	3.23036
boer het klimaatsverandering ervaar	ja	11	3.09090	0.70064	0.21125	2.62020	3.56161
boer het klimaatsverandering ervaar	nee	9	2.55555	0.88191	0.29397	1.87765	3.23345

Vraag 2.2.2 | boer het klimaatsverandering ervaar

boer het klimaatsverandering ervaar; LS Means



boer het klimaatsverandering ervaar; LS Means (subset in Heckman.stw)

boer het klimaatsverandering ervaar; LS Means (subset in Heckman.stw)
Current effect: F(1, 18)=.58235, p=.45528
Effective hypothesis decomposition

Cell No.	boer het klimaatsveranderin ervaar	Vraag 2.2.2 Mean	Vraag 2.2.2 Std.Err.	Vraag 2.2.2 -95.00%	Vraag 2.2.2 +95.00%	N
1	ja	3.00000	0.19534	2.58959	3.41040	11
2	nee	2.77777	0.21596	2.32406	3.23149	9

Descriptive Statistics (subset in Heckman.stw)

Descriptive Statistics (subset in Heckman.stw)

Effect	Level of Factor	N	Vraag 2.2.2 Mean	Vraag 2.2.2 Std.Dev.	Vraag 2.2.2 Std.Err	Vraag 2.2.2 -95.00%	Vraag 2.2.2 +95.00%
Total		20	2.90000	0.64072	0.14327	2.60013	3.19986
boer het klimaatsverandering ervaar	ja	11	3.00000	0.44721	0.13484	2.69955	3.30044
boer het klimaatsverandering ervaar	nee	9	2.77777	0.83333	0.27777	2.13722	3.41833

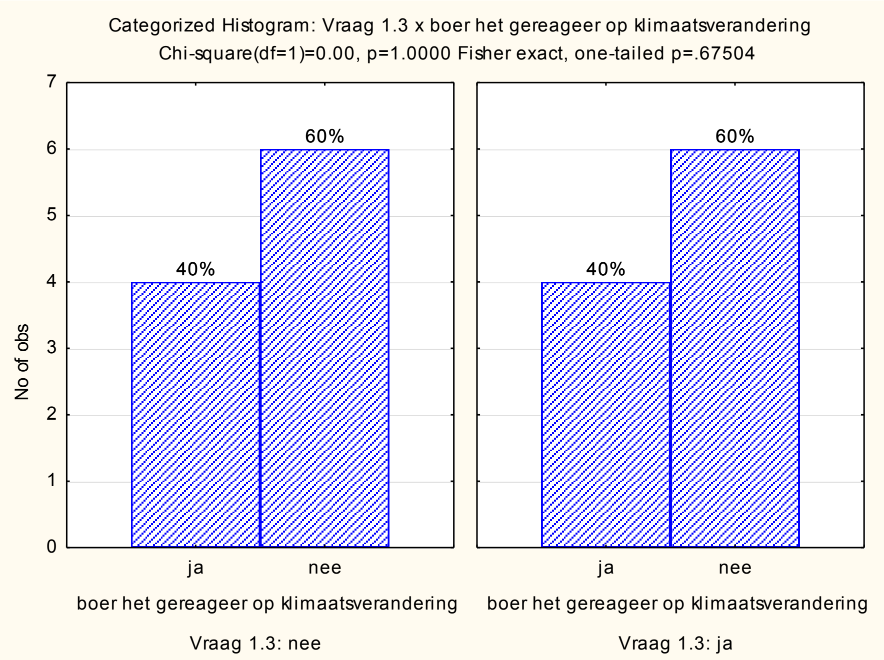
het gereageer

Vraag 1.3 | boer het gereageer op klimaatsverandering

2-Way Summary Table: Observed Frequencies (subset in Heckman.stw)

	Marked cells have counts > 10. Chi-square(df=1)=0		
Vraag 1.3	boer het gereagee op klimaatsveranderin ja	boer het gereagee op klimaatsveranderin nee	Row Totals
nee	4	6	10
Row %	40.00%	60.00%	
ja	4	6	10
Row %	40.00%	60.00%	
Totals	8	12	20

Categorized Histogram: Vraag 1.3 x boer het gereageer op klimaatsverandering



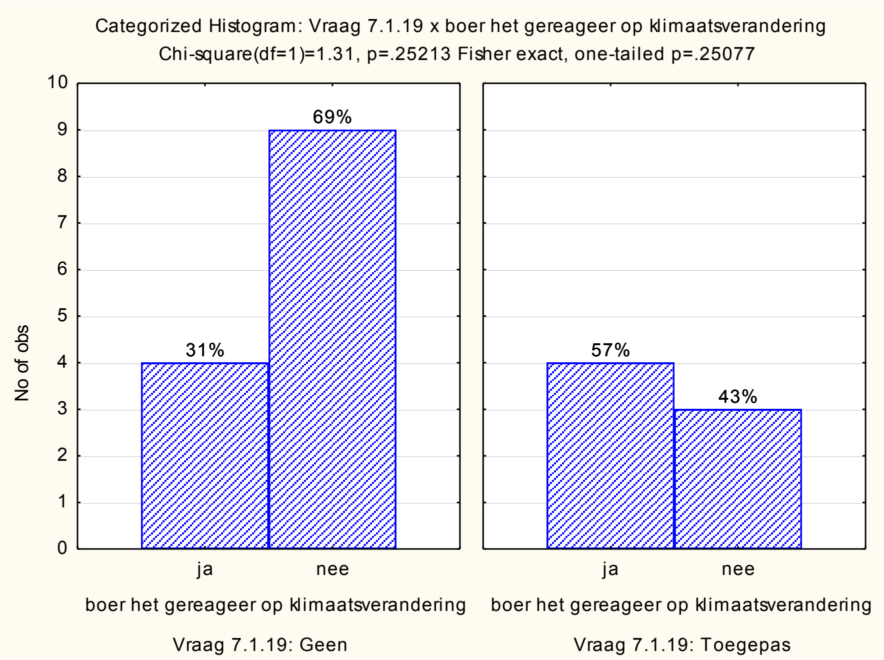
Vraag 7.1.19 | boer het gereageer op klimaatsverandering

2-Way Summary Table: Observed Frequencies (subset in Heckman.stw)

Marked cells have counts > 10. Chi-square(df=1)=1

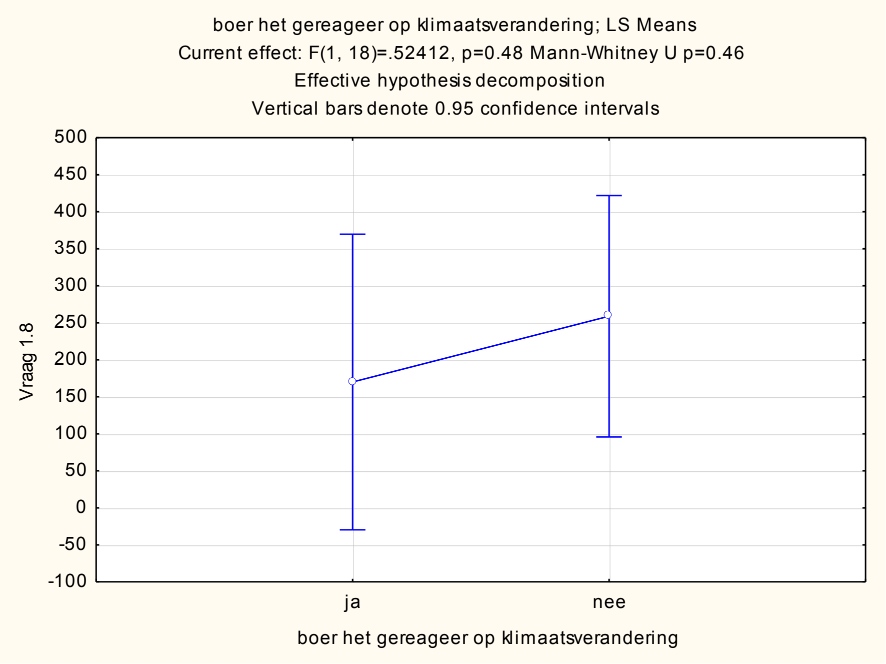
Vraag 7.1.19	boer het gereagee op klimaatsveranderin ja	boer het gereagee op klimaatsveranderin nee	Row Totals
Geen	4	9	13
Row %	30.77%	69.23%	
Toegepas	4	3	7
Row %	57.14%	42.86%	
Totals	8	12	20

Categorized Histogram: Vraag 7.1.19 x boer het gereageer op klimaatsverandering

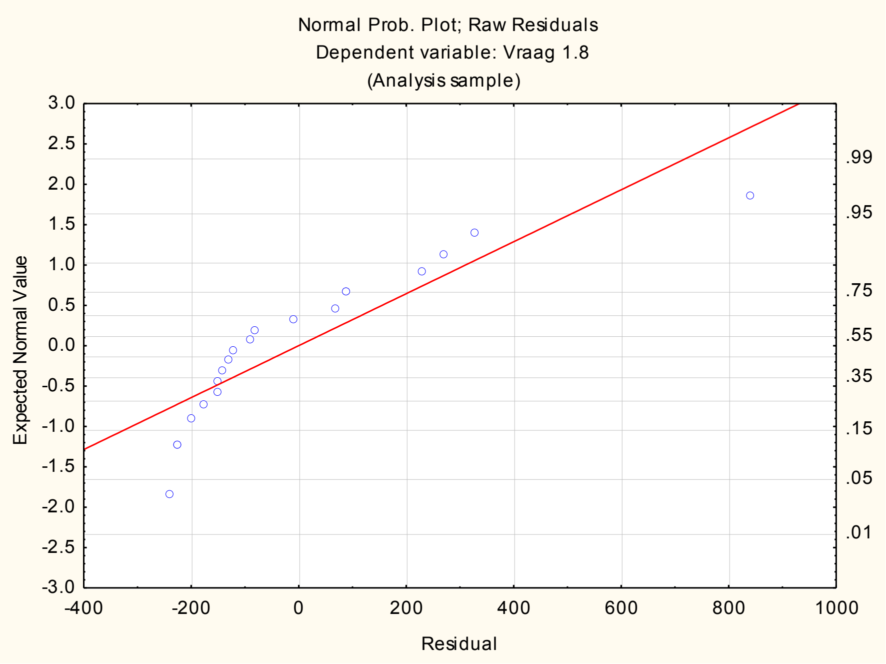


Vraag 1.8 | boer het gereageer op klimaatsverandering

boer het gereageer op klimaatsverandering; LS Means



Normal Prob. Plot; Raw Residuals



Tests of Homogeneity of Variances (subset in Heckman.stw)

	Tests of Homogeneity of Variances (subset in Effect: "boer het gereageer op klimaatsverand				
	Hartley F-max	Cochran C	Bartlett Chi-Sqr.	df	p
Vraag 1.8	2.69898	0.72965	1.78985	1	0.18094

boer het gereageer op klimaatsverandering; LS Means (subset in Heckman.stw)

boer het gereageer op klimaatsverandering; LS Means (subset in Heckma
Current effect: F(1, 18)=.52412, p=.47840
Effective hypothesis decomposition

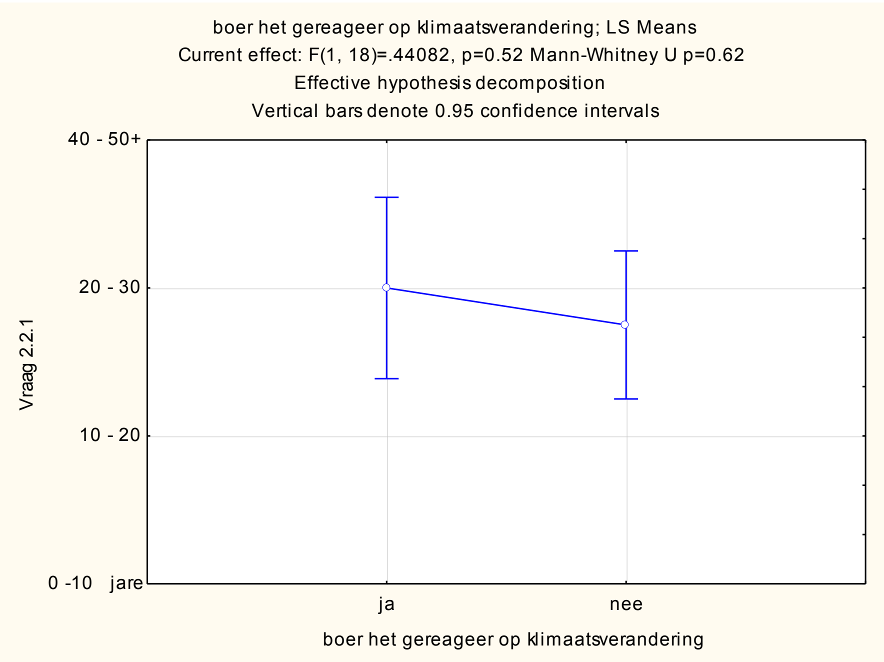
Cell No.	boer het gereagee op klimaatsveranderin g	Vraag 1.8 Mean	Vraag 1.8 Std.Err.	Vraag 1.8 -95.00%	Vraag 1.8 +95.00%	N
1	ja	170.000(	95.0467(	-29.6858	369.6858	8
2	nee	258.8333	77.6053	95.7905	421.8761	12

Descriptive Statistics (subset in Heckman.stw)

Effect	Level of Factor	N	Vraag 1.8 Mean	Vraag 1.8 Std.Dev.	Vraag 1.8 Std.Err	Vraag 1.8 -95.00%	Vraag 1.8 +95.00%
Total		20	223.300	265.444	59.3552	99.0680	347.532
boer het gereageer op klimaatsverandering	ja	8	170.000	188.300	66.5743	12.5767	327.423
boer het gereageer op klimaatsverandering	nee	12	258.833	309.351	89.3019	62.2809	455.385

Vraag 2.2.1 | boer het gereageer op klimaatsverandering

boer het gereageer op klimaatsverandering; LS Means



boer het gereageer op klimaatsverandering; LS Means (subset in Heckman.stw)

boer het gereageer op klimaatsverandering; LS Means (subset in Heckman.s
Current effect: F(1, 18)=.44082, p=.51514
Effective hypothesis decomposition

Cell No.	boer het gereagee op klimaatsveranderin g	Vraag 2.2.1 Mean	Vraag 2.2.1 Std.Err.	Vraag 2.2.1 -95.00%	Vraag 2.2.1 +95.00%	N
1	ja	3.00000(	0.29166	2.38723	3.61276	8
2	nee	2.75000(	0.23814	2.24967	3.25032	12

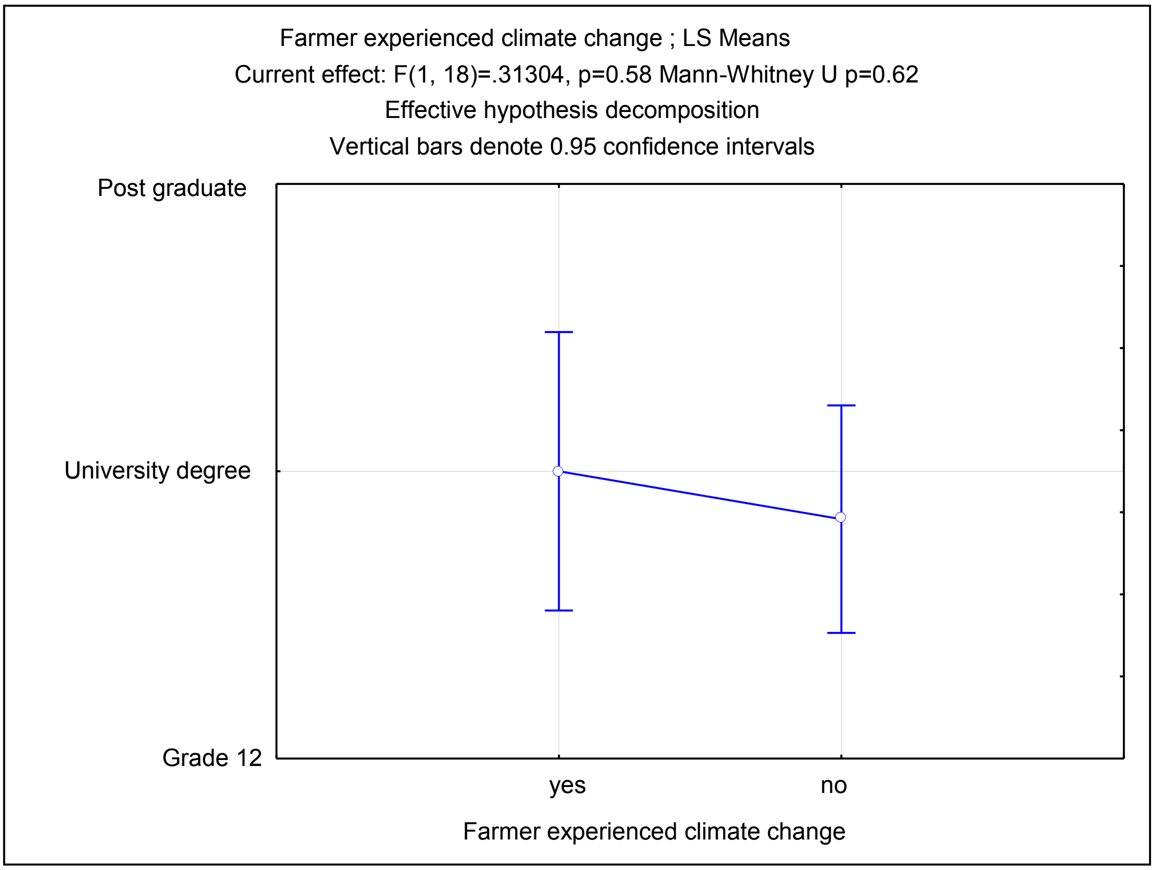
Descriptive Statistics (subset in Heckman.stw)

Descriptive Statistics (subset in Heckman.stw)

Effect	Level of Factor	N	Vraag 2.2.1 Mean	Vraag 2.2.1 Std.Dev.	Vraag 2.2.1 Std.Err	Vraag 2.2.1 -95.00%	Vraag 2.2.1 +95.00%
Total		20	2.85000	0.81272	0.18173	2.46963	3.23036
boer het gereageer op klimaatsverandering	ja	8	3.00000	0.75592	0.26726	2.36802	3.63197
boer het gereageer op klimaatsverandering	nee	12	2.75000	0.86602	0.25000	2.19975	3.30024

Vraag 2.2.2 | boer het gereageer op klimaatsverandering

boer het gereageer op klimaatsverandering; LS Means



boer het gereageer op klimaatsverandering; LS Means (subset in Heckman.stw)

boer het gereageer op klimaatsverandering; LS Means (subset in Heckman.s
Current effect: F(1, 18)=.31304, p=.58271
Effective hypothesis decomposition

Cell No.	boer het gereagee op klimaatsveranderin	Vraag 2.2.2 Mean	Vraag 2.2.2 Std.Err.	Vraag 2.2.2 -95.00%	Vraag 2.2.2 +95.00%	N
1	ja	3.00000	0.23074	2.51523	3.48476	8
2	nee	2.83333	0.18839	2.43752	3.22914	12

Descriptive Statistics (subset in Heckman.stw)

Descriptive Statistics (subset in Heckman.stw)

Effect	Level of Factor	N	Vraag 2.2.2 Mean	Vraag 2.2.2 Std.Dev.	Vraag 2.2.2 Std.Err	Vraag 2.2.2 -95.00%	Vraag 2.2.2 +95.00%
Total		20	2.90000	0.64072	0.14327	2.60013	3.19986
boer het gereageer op klimaatsverandering	ja	8	3.00000	0.53452	0.18898	2.55312	3.44687
boer het gereageer op klimaatsverandering	nee	12	2.83333	0.71774	0.20719	2.37730	3.28936

2 step Heckman probit

```
------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
gereageer    |
        v1_3 |   .8792407   .3997848     2.20   0.028      .095677    1.662804
        v1_8 |  -.0028618   .0029434    -0.97   0.331    -.0086308    .0029072
      v2_2_1 |   .5428874   .7463853     0.73   0.467    -.9200009    2.005776
      v2_2_2 |   1.352083   1.031444     1.31   0.190    -.6695104    3.373676
     v7_1_19 |   .8256997   .2438274     3.39   0.001     .3478068    1.303593
       _cons |  -5.497656   5.820182    -0.94   0.345      -16.905    5.909691
-------------+----------------------------------------------------------------
ervaar       |
        v1_3 |  -.1240113   .9204898    -0.13   0.893    -1.928138    1.680116
        v1_8 |  -.0028269   .0021609    -1.31   0.191    -.0070622    .0014084
      v2_2_1 |   .9475179   .5673534     1.67   0.095    -.1644744     2.05951
      v2_2_2 |   1.021098   .6232414     1.64   0.101    -.2004327    2.242629
       _cons |  -4.837434   2.561759    -1.89   0.059     -9.85839    .1835217
```