Western Cape Government
Environmental Affairs and Development Planning

BETTER TOGETHER.

A Climate Change Strategy and Action Plan for the Western Cape

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This report was prepared for the Department of Environmental Affairs and Development Planning by OneWorld Sustainable Investments

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A climate change response strategy and action plan for the Western Cape

Responding to the challenge of climate change and sustainable development in the Western Cape

Prepared for the Department of Environmental Affairs and Development Planning, Western Cape, by OneWorld Sustainable Investments

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Foreword

It is clear that climate change will affect the Western Cape Province.

Climate Change is happening now and is one of the biggest challenges facing the international community. Even with the achievement of significant global greenhouse gas emission reduction targets, there will still be changes to the global climate and to our climate here in the Western Cape. These changes will affect everyone in our community - government, industry, community groups and individuals - and all sections of the community have a part to play in responding to climate change.

To achieve this vision, we need to act now using our existing knowledge. We then need to set out longer-term strategies to continue to improve our understanding of the impacts of climate change. We need to plan and adapt to the expected changes.

The Western Cape has relatively low levels of greenhouse gas emissions when compared to other parts of South Africa, but it is incumbent on us to look for local opportunities to maintain low greenhouse gas emission levels. We will also continue to participate in national policy development and strategies on greenhouse gas mitigation.

For the immediate future, the focus must be on planning to adapt to climate change and its impacts using the best available knowledge.

This Strategy builds on the work already done in the province and sets out our direction now and for the longer term. It sets out the Government's commitment to:

- Leading the response to climate change in partnership with other spheres of government, research institutions, industry and the community
- Planning and adapting now and into the future to minimise possible adverse impacts of climate change and to position the province to take advantage of emerging opportunities
- Focusing on water as our already scarce resource that is extremely vulnerable to climate change impacts
- Developing renewable energy and energy efficiency options and minimising our greenhouse gas emission levels
- Continuing to improve our knowledge of the impacts of climate change
- Informing and involving our industry sectors and the community to ensure they are better able to adapt and respond to the challenges associated with a changing climate.

The Strategy promotes a strategic outlook as well as practical actions, land use and development planning based on a risk management approach and a culture of innovation to capture opportunities. It aligns with the goals established through the Sustainable Development Strategy for the Western Cape and will provide a sound foundation for future climate change responses in the province.

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Abbreviations and acronyms

Abbreviation	Definition
ARC	Agricultural Research Council
BEE	Black Economic Empowerment
BEEH	School of Bio-resources, Engineering and Environmental Hydrology
CBD	Central Business district
CBO	Community Based Organisations
CC	Climate Change
CDM	Clean Development Mechanism
CER	Certified Emission Reductions
CITES	Convention on International Trade in Endangered Species
CO_2	Carbon Dioxide
COSATU	Congress of South African Trade Unions
CWDM	Cape Winelands District Municipality
DA	Department of Agriculture
DAPPS	Dynamic Air Pollution Prediction System
DEA&DP	Department of Environmental Affairs and Development Planning
DEAT	Department of Environmental Affairs and Tourism
DFPT	Deciduous Fruit Producers Trust
DME	Department of Minerals and Energy
DOL&H	Department of Local Government and Housing
DOT	Department of Transport
DPSIR	Drivers, Pressures, State, Impacts, Response
DST	Department of Science and Technology
DWAF	Department of Water Affairs and Forestry
EB	Executive Board
EE	Energy Efficiency
ENSO	El Niño-Southern Oscillation
EU	European Union
EUA	European Union Allowances
F gases	Fluorines
FAR	Foundation for Arable Research
G8	Group of 8 Developed Industrial Nations
GCM	General Circulation Models (of the atmosphere)
GDP	Gross Domestic Product
GHG	Green House Gas
GIS	Geographic Information System
GISP	Global Invasive Species Program
GW	Global Warming
GWU	General Workers Union
IAM	Integrated Assessment Model
IAS	Integrated Assessment System
ICCAT	International Commission for the Conservation of Atlantic Tunas
IDP	Integrated Development Plan
IEMI	Integrated Environmental Management Series
IPCC	Inter-Governmental Panel on Climate Change
IPP	Independent Power Producer

ITUF	Independent Trade Union Federation
IVA	Impacts, Vulnerability and Adaptation
LUPO	Land Use and Planning Ordinance
M&A	Mitigation and Adaptation
MPA	Marine Protected Areas
MSW	Municipal Solid Waste
MW	Megawatt
NACTU	National African Confederation of Trade Unions
N2O	Nitrogen Dioxide
NBT	National Board of Transport
NEMA	National Environmental Management Act
NEPAD	New Partnership for African Development
NERSA	National Energy Regulator for South Africa
NGO	Non Governmental Organisation
NLTTA	National Land Transport Transition Act
NPP	Net Primary Productivity
NUM	National Union of Mineworkers
NUMSA	National Union of Metal Workers of South Africa
NWA	National Water Act
OECD	Organisation for Economic Cooperation and Development
PCCC	Provincial Climate Change Committee
PDC	Provincial Development Council
PDI	Previously Disadvantaged Individuals
PESTLE	Political, Economic, Social, Technological, Legal, Environmental
PGC	Pacific Geo-science Centre
PV	Photovoltaic
RE	Renewable Energy
RED	Regional Electricity Distributor
SA	South Africa
SACSCC	South African Country Study on Climate Change
SAMWU	South African Municipal Workers Union
SAPP	Southern African Power Pool
SAR	Second Assessment Report of the IPCC
SATAWU	South African Transport Workers Union
SWH	Solar water heater
TAR	Third Assessment Report of the IPCC
TCA	Total Catch Allowance
TNA	Technology Needs Assessment
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention for Climate Change
US	United States
VER	Voluntary Emission Reductions
WC	Western Cape
WCAWU	Western Cape Agriculture & Allied Workers Union
WCDA	Western Cape Department of Agriculture
WCDM	West Coast District Municipality
WMA	Water Management Area
WRC	Water Research Commission
WSSA	Water and Sanitation Services South Africa
WWF	World Wide Fund for Nature

Executive Summary

Setting the scene for the Response Strategy and Action Plan

Climate change in the Western Cape – why a response strategy is necessary

Climate change is one of the biggest challenges facing the international community. Although media coverage and talk is generally about the future impacts of climate change, our climate is in fact already changing and a further level of climate change is inevitable – whatever the global response to reducing greenhouse gas emissions. Research has indicated that the south-western corners of the three continents south of the equator are likely to be the most affected by climate change. This has already been evidenced by the impact on Perth in Australia. Similarly, because of its location, the Western Cape is likely to be particularly vulnerable to climate change - and changes to the provincial climate will affect everyone in our community.

Much work is being conducted on a global scale to evaluate global warming and its impacts. Significant local variation around these global generalisations may occur and the complexity of the regional response needs to be carefully evaluated. The details underlying this continue to emerge as research continues and much remains still to be understood. Nonetheless, on the existing scientific understanding it is increasingly clear that there will be continued changes in the regional climate which, in nearly all respects, will impose additional stress with dominantly negative (and some positive) consequences for the province unless immediate steps are taken to optimise the opportunities which underlie these challenges. This necessitates a strategic response on the part of the provincial and national government, predicated on the best scientific understanding of the regional expressions of climate change.

There is little doubt that the Western Cape will face some degree of climate change in the 2030-2045 period, irrespective of local or global efforts to reduce greenhouse gas emissions. Although the scale and exact manifestation of the change is less certain, the application of a range of climate models to the province makes it possible to identify a number of stress factors with likely results:

- An increase in the annual average temperature of at least 1 °C by 2050 (the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report released in February this year shows an expected increase of between 3 and 5 °C by 2100)
- Possible increase in the frequency and intensity of extreme events
- An increase in conditions conducive to wildfires (higher temperatures and increased wind velocity)
- Reduced rainfall in the western parts of the Western Cape
- Decreased water resources

- Reduced soil moisture from an increase in temperature coupled with a decrease in average precipitation

- Temperature impacts on crop activities – crop burn, drought, pests and microbes resulting in yield reductions, and loss of rural livelihoods.

The above statements should not be regarded as forecasts but rather as indications of possible directions and scale of change. The most useful approach is to use these projections as an experimental basis for assessing additional risk – that is, the potential exposure to hazards to life, biodiversity or economic interests that climatic changes on this scale could pose.

The timeline parameter for the response strategy is the 2030-2045 period. 2030 is the earliest anchor year to which climate change projections can realistically be scaled back from global climate models, which look at 2045 and beyond. 2030 is also a time horizon within which policy, economic and business decisions can realistically be made.

Toward an integrated adaptation and mitigation action plan and response strategy

There are two key ways to respond to changing climate. One is through **mitigation** — the reduction of the intensity of climate change effects by reducing greenhouse gas emissions. This approach recognises that in the longer term, countries — and individuals — can stem the tide of climate change through activities that reduce the quantities of greenhouse gases we produce. This approach implies radical changes in the use of technology, and employing practices that actively reduce carbon emissions such as innovative industrial processes, the use of cleaner fuels, the implementation of energy efficiency measures and the enforcement of fuel-efficient vehicles.

An additional but equally important response is **adaptation**, which is the process of recognising the effects of climate change and adapting to these changed conditions. Adaptation implies **behavioural change** in response to the changed conditions, such as the implementation of alternative farming practices, appropriate measures in development planning, changes in demand side management practices and so on. (Demand-side management is the practice of controlling the use of resources such as water, and of utilities such as electricity by controlling the demand for these resources). This implies behavioural change by the consumer rather than the supplier. For example, making electricity more expensive during peak hours would result in decreased use during those times.

The long 'lead-in time' of climate change means that a certain level of change is inevitable – meaning that we will have to adapt in order to maintain economic stability and enjoy a measure of continued growth. Adaptation, however, is not enough. It will see the Western Cape through effective risk management if integrated effectively in decision planning, stewardship and resource conservation decision- making and implementation processes, but it needs to be coupled with mitigation strategies that aim to reduce the provincial carbon footprint - the Western Cape is a relatively low emitter in terms of local direct emissions. However its contribution to national emissions is significant given the amount of electricity that is imported from Mpumalanga and consumed locally (over 90% of the province's electricity is imported). South Africa is a significant global emitter (19th biggest GHG emitter in the world)[1] with over 70% of emissions arising from electricity production.

[1] Climate Change Indicator Analysis Database, World Research Institute

The balance between mitigation and adaptation needs to be carefully weighed. Postponing a mitigation response significantly impacts the future time when climate change can be controlled and greatly increases the risk of serious and irreversible climate change. Mitigation measures are critical, particularly as the Western Cape strengthens its energy supply and security base through infrastructure investment. Here only clean technologies and deployment of renewable resources can be considered options in the context of climate change.

While mitigation efforts are not going to be effective in the short term (10 – 30 years), we must make progress in developing technologies and approaches to reducing carbon emissions. International concern is already leading valuable markets in the European Union to impose carbon emission reduction targets on their suppliers. The Western Cape stands to lose market share on agricultural goods, for example, if no attempt is to be made to achieve at least carbon neutrality (i.e. no net emission of carbon for a produced good).

In the Western Cape Climate Change Strategy and Action Plan, less than 15% of the total budget for the Western Cape government is allocated to mitigation. The remaining 85% goes towards adaptation measures: increasing capacity, strengthening resilience and minimising risk.

Both mitigation and adaptation require that government leads by example. It needs to drive behavioural change and action through informed policy and incentive instruments as well as through demonstrable activities such as government waste recycling programmes and the use of alternative energy sources such as solar water heaters in government buildings.

Dealing with risk, uncertainty and vulnerability

A strategic response needs to be cognisant of the uncertainties – but also of the inherent risks – of climate change. Dealing with uncertainty necessitates a focus on measures and actions that should happen in any case, where climate change enhances the urgency of the action and response. To be effective, the strategy and action plan must result in climate risk being considered as a normal part of decision-making, thus allowing government, business and individuals to reflect their risk preferences as they would for any other risk assessment. Both angles described are strategies to facilitate the reduction of the complexity of response to a manageable level. Effectively, this means ‘mainstreaming’ climate change into other dimensions of strategic planning and risk management – dimensions that are already in place.

Many of our human and natural systems are strongly influenced by climate. Natural ecosystems evolve in variable and generally slowly changing climate patterns and industries and communities are also affected by climate factors – for example influencing productivity and reliability of supply. There is also an underlying expectation that infrastructure and cities will safely and efficiently cope with extreme weather events and that lives will adapt to severe events such as intense pollution episodes.

Prioritising response actions to climate change requires the following:

- identification of vulnerable systems (both natural and human) and the estimation of costs if these systems fail

- identification of the scope to reduce risks, strengthen adaptive capacity and capture potential benefits.

Vulnerability is a function of exposure to climate factors, sensitivity to change and capacity to adapt to that change. Vulnerable systems are those that are highly exposed, sensitive and less able to adapt. Developing a response strategy that encompasses adaptation must identify sectors and systems that are vulnerable to change coupled with an examination of the scope to increase their resilience. A further consideration in the prioritisation process is the identification of vulnerable systems or regions whose failure or reduction is likely to carry the most significant consequences.

Priority systems and sectors in the Western Cape

Vulnerable systems identified as priorities for this strategy are:

- Natural systems – water, biodiversity, and coastal and marine systems and resources
- Economic sectors – agriculture, tourism and fisheries
- Economic resources and infrastructure – energy, transport, health and air quality
- The built environment, livelihoods and disasters – social systems, extreme events (floods, fires).

The development of the Western Cape response strategy and action plan involved the application of a vulnerability framework to identify priorities in dealing with climate change. The following systems and sectors – natural and human – have been identified as priorities and these reflect considerations of climate vulnerability, the significance of the systems and sectors at risk and the required need for government intervention to encourage a timely and efficient response:

Natural systems and resources

The availability of ***water*** is essential for many industries, livelihoods and other natural resources. Many cities and regions in the Western Cape face water stress already. In most cases, climate change will increase this pressure through increased temperature, possible reductions in rainfall, drying, and related (possible) increase in extreme weather events. Reduced water supply and a drought as severe as the one experienced in the province in the 1920s can have catastrophic short- and medium-term effects in terms of human and economic losses.

Options for responding to water stresses (as already experienced) could include the systematic inclusion of climate risk on both the supply and demand side in all the province's major catchments. Much work is already being done in the area but climate risk strengthens the need to harness existing supply, to manage resources more efficiently, to implement the ecological reserve and to develop more robust catchment models. It also necessitates improved decision-making support tools.

Eco-systems and biodiversity are likely to come under significant pressure from climate change, which is likely to proceed at a rate that will exceed the natural adaptive capacity of many organisms and systems. In some cases, there may be scope to assist the adaptation of vulnerable systems and species and the threat of climate change should be specifically factored into related planning and actions. Managing Invasive Alien Species in an integrated manner based on prevention, early response and removal is critical to protecting the

province's delicate and unique fynbos eco-system, for example, which in turn protects natural water supply.

Other options for managing biodiversity in the face of climate risks include extending protected areas, managing wetlands consistently and effectively and increasing the provincial fire risk ratings.

Coastal and marine systems and resources are exposed to extreme events, which may increase in terms of frequency and intensity with increased salt-water intrusion, raised groundwater tables and increased coastal erosion. The province's coastline is sensitive to sea level rises, which will impact on coastal ecology – particularly where developments are too close to high-water lines. The impacts of climate change are also economic – the Western Cape's 50 estuaries are particularly vulnerable to climate change and these are important feeding and nursery grounds for many shellfish, fish and bird species and are economically important as fisheries.

Possible options for mitigating climate risk include integrating climate risk considerations into coastal development planning and strengthening already existing coastal assets and infrastructure. Also important will be to refine the understanding of socio-economic impacts of reduced fisheries – particularly on the West Coast (the hub of the South African fishing industry) – as a possible consequence of climate change.

Economic sectors

Agriculture systems have an inherent level of adaptive capacity to climate variability and change. This is evidenced through changes in land management practices, crop and cultivar choices and (to a lesser extent in this province) in the selection of technologies and species to increase efficiencies of water use. The degree of climate change does however test the limits of this autonomous adaptive capacity and many aspects of agricultural life in the province are already found to be at (or close to) their thresholds. The agri-business units at highest risk will be:

- Those that are already under stress economically and/or biophysically as a result of land degradation, salination and loss of biodiversity
- Those at (or close to) the threshold of their climate tolerance
- Emerging farmers who may have limited capacity, resources and skills to adapt to and withstand economic pressures
- Rural livelihoods that depend on agri-business-based economic activity for jobs
- Commercial farmers where significant long term investments have been and are being made – for example in irrigation systems, processing facilities and some cultivars
- Agri-business activity that is dependent on the export market which is adapting to climate change in itself – for example importers such as Marks & Spencer moving toward a carbon-neutral status and transferring this pressure onto suppliers and the ever increasing focus internationally on reducing 'food-miles'.

Options and strategies to increase resilience and reduce the vulnerability of this sector should include integrated land care management, research on pests and microbes that are particularly sensitive to climate change, research on cultivars that are capable of handling temperature increases and drought and more efficient irrigation for water conservation.

Fisheries, as discussed in the coastal and marine section, are sensitive to climate change and risks. Communities that depend on the resource as well as commercial industry are at risk. The last 8-10 years have seen significant financial investment in the sector and that investment is potentially at risk due to climate impacts.

Options for adaptation include researching the socio-economic impacts, understanding the adaptive capacity of fishing stock (for example, migrating eastwards) and factoring climate risks into calculating allocation allowances.

The ***tourism sector*** in the Western Cape is largely dependent on international (European) tourists who may respond to international adaptation and mitigation responses to climate change. The introduction of a carbon tax on air travel may, for example, encourage long-haul tourists to seek destinations closer to home, thus making travel easier on the pocket. Tourism also places stress on scarce resources such as water. Increased temperatures in the province may lead to an increased energy demand, for example, in greater demand for air conditioning. Increased air pollution may impact negatively on tourism, and threats that climate change poses to the province's coastal infrastructure and beaches are also of concern.

Mitigation and adaptation responses could include factoring climate risks into development planning and approval processes in the industry; researching the socio-economic impacts of climate change on tourism and monitoring climate impacts, responses and tourism demand closely in the province. Alternate sustainable energy development that includes applications for the tourism industry (such as solar water heaters) is an important mitigating response strategy for the sector.

Economic resources and infrastructure

Demand for ***energy*** is temperature sensitive – increasingly so with the penetration of commercial and domestic air conditioning with peaks changing from winter to summer and getting steeper. Alternate water supply options such as desalination plants are under consideration due to increased water stresses but these plants are energy intensive. Electricity supply is sensitive to both extreme weather related events and in some cases temperature itself as it degrades transmission capacity. Infrastructure (electricity distribution) is also susceptible to the impacts of increased bush fires. The Western Cape's energy infrastructure has demonstrated its reduced capacity to sustain cumulative impacts. The failure in supply of high quality energy that the province has come to rely on brings much higher social and economic costs than ever previously experienced. The electricity sector is subject to regulation and it is not clear that the regulators are as yet sensitive to the pressures that may be further placed on infrastructure by climate change, and hence the possible need to allow some level of redundant capacity.

Climate risks must be factored into the Western Cape's energy planning. Mitigation and adaptation responses include strengthening the province's energy security through diversifying its supply base into resources already identified as available – natural gas, wind and solar, to name the 'tried and tested' resources available to the province. Managing efficiency through demand side management programmes and maximizing opportunities in an already-established solar water heating industry are also solutions with clear evidence for implementation.

The ***transport sector*** is already under stress and development planning has impacted negatively on the sector in that communities are being established further and further away

from economic nodes. The sector is a significant contributor to provincial greenhouse gas emissions and growth in demand will only serve to exacerbate this problem. In addition, local air quality is impacted on by transport.

Options for mitigation in the sector include introducing cleaner fuel programmes in the provincial fuel mix and commercialising innovation in the province such as the development of South Africa's first 'home-grown' electric car.[2]

Air quality can be sensitive to increased temperatures, increased greenhouse gas emissions as well as to an increased demand for local fuels such as paraffin and wood. Local and indoor air quality impacts on ***health*** and could, as mentioned, affect economic activities such as tourism. Climate change and failure to mitigate may contribute to increased severe air pollution episodes, and early warning systems can help mitigate this.

Options include increasing the number of monitoring stations in the province, disseminating air quality data effectively and introducing cleaner fuel programmes in peri-urban and rural areas.

Other health impacts include those that arise from increased penetration of Invasive Alien Species (IAS) as a result of climate impacts such as increased temperatures combined with drying. Some species contaminate water, increasing the risk of disease. Poor air quality (pollution) contributes to increases in respiratory diseases. Other vector-borne diseases may also arise as a result of climate impacts.

Introducing a cohesive programme for managing IAS in the province that has a clear vision and budget is an important adaptation option.

The built environment, livelihoods and extreme events

Exposure of the province's cities and settlements to climate risks is high but the sensitivity to change is dependent on the way climate change impacts on extreme events. The ***built environment*** and urban areas can be seen as machines to manage and control climate impacts. Cities and infrastructure are built to accepted risk limits based on climate patterns and limits as we have known them. Some of the provincial infrastructure and various communities are already threatened by having been established on unsuitable sites, due to poor planning conditions (examples include housing developments on sites vulnerable to flooding or coastal infrastructure below the high water mark), and climate change is set to alter these limits, which are in some cases already stretched. Damage, injury and death as a result of increased extreme events hold particularly strong consequences for ***livelihoods, settlements, and emergency services*** that are already beyond their thresholds. In many of the provincial urban and rural centres, increases in severe weather events linked with climate change (such as fires, heavy rainfall, high winds and increased heat waves) could cause significant damage. This is worsened in areas that have increased population density, such as Cape Town and George.

Options to adapt include integrating climate risks into development planning and approval processes; enhancing the emergency services and integrating climate risk into disaster management processes and systems; and maintaining livelihoods (such as rural livelihoods) as far as possible so as to minimize population stress in urban centres.

[2] Optimal Energy in Cape Town is developing a first prototype with funding from the Innovation Fund.

Pulling risk and vulnerability together in the Western Cape

Climate change can influence and react with a range of macro-variables. In the Western Cape it can be a driver of internal migration – should rural livelihoods decline – and production patterns[3]. Climate change could interact with demographic and behavioural trends with implications for future health care and community service needs. Increased demands on the province's already-threatened energy security and water supply systems will have economic and social consequences. In addition, the province is likely to be influenced by international climate impacts and responses and the related effect on commodity prices, demand and volumes, requisite changes to production processes and socio-economic factors, including pressure for disaster relief and migration.

The ***stakeholder consultations*** in the process of developing the response strategy and action plan saw a common thread emerging: the desire for government to lead by example coupled with consistency and follow-through on strategies, plans and policies adopted. This requires strong provincial government leadership on climate change response, which can manifest through:

- Demonstrated integration of climate risks in decision-making and planning across the different tiers of government
- Leadership by example at a most senior level of government
- Improved understanding and knowledge of climate science, related risks and impacts and the establishment of clear government – science dialogue
- Co-ordinated monitoring, review and revisiting of strategies for identifying and managing risk in vulnerable systems and sectors
- Provision of decision-support tools and climate change related information that could assist local government, developers, the private sectors and households to integrate climate risk into key decisions and resource management
- Dissemination of information about climate change, weather and air quality
- Communications, education and awareness around climate change in all sectors and communities.

Approach and methodology to developing a provincial response strategy

Stakeholder consultation, international best practice, a comprehensive literature review and expert opinion have informed much of the work in developing the strategy. A critical success factor for the roll-out of the response strategy is its integration with other relevant strategic planning processes and initiatives, planned and future, in the Western Cape and nationally. A close review of these therefore further underpinned the strategy development.

Climate science analysis provided the basis for assessing impacts and developing the adaptation and mitigation strategy. This analysis began with climate models and global emission scenario models and then applied multi-disciplinary approaches in linking these models to spatial models such as biodiversity and crop productivity. Sensitivity thresholds of the prioritised vulnerable natural and human systems were then tested. Climate science modeling information is represented through a set of robust statements about expected climate change in the Western Cape and some climate scenarios (i.e. outlines of future

[3] Such as some farming communities moving toward a 'carbon neutral' or 'zero carbon' production status.

climate development for the province). This climate change information was assessed as integrated with socio-economic models for the province (i.e. comprising environmental changes linked with socio-economic changes) so as to provide the context in which climate change will have its impact.

Stakeholder engagement and discussions with government officials, civil society, community-based organisations, development agencies and private sector industry players were used to provide a rapid broad-based assessment of the key issues and priorities as perceived by experts in the related fields, politicians, local authorities and strategy administrators, industry players and communities. Stakeholder engagement also provided the platform for developing the communication strategy and awareness campaigns.

International best practice and literature review facilitated the assessment of countries and regions that face similar bio-physical and/or socio-economic challenges to the Western Cape. Possible partnerships were identified with countries and regions such as Peru, Chile, Western Australia, California, Morocco and Queensland, which can assist the province significantly in its ability to leap-frog certain research and assessment processes and to deal more robustly and cost effectively with climate change risks. The Western Cape is fortunate in that it is home to strong research, scientific and socio-economic analytical ***expertise*** and is home to some of the international community's most renowned climate scientists and policy makers. This provides a sound platform for accessing international research and the critical success factor lies in the ability to identify suitable partnerships.

A response options matrix

A vast number of possible response options emerged from the research, stakeholder consultations and expert review processes (around 280 options including both mitigation and adaptation responses). These options populate the full matrix of possible climate change response actions for the Western Cape. These are grouped for ease of reference on a sectoral/systems basis. These sectors and systems each underwent risk and vulnerability assessments which were informed by research and analysis in each cluster based on the application of a framework that examined political, economic, social, technological, legal and environmental indicators (PESTLE analysis). This facilitated the basis for an initial level of prioritisation within sectors and systems based on an understanding of the sensitivities and adaptive capacities within each.

Prioritising and evaluating options

The matrix was further filtered using a multi-criteria analysis model that comprised:

- Cost-effective analysis – *assessing the cost of taking action versus the cost of a 'business as usual' approach*
- Ease of implementation – *who will be the option custodian and can the option be implemented on a practical level?*
- Social impact – *will the implementation of the action have a positive or negative social impact and will it compromise the goals of sustainable development within the province?*
- Environmental effectiveness – *will the measure or action have a neutral or positive environmental impact when considered holistically in the context of the environment in which it will take effect?*

An example of an option that did not meet the criteria in this filter process is the assessment of local supply side of biofuels in a cleaner fuel programme for the Western Cape. Biofuel production using known feedstock is water intensive and can also be energy intensive, thus

making a net energy balance and a neutral or positive environmental footprint difficult and, in some instances, close to impossible. Creating a viable local supply of biofuels requires consistent and high agricultural yields, and the trend of planting crops on marginal lands at the expense of emerging farmers does not facilitate the achievement of this objective; thus also indicative of a negative social impact and potentially increasing rather than reducing poverty.

The prioritised options matrix (around 40 options) was also taken through a process of stakeholder workshops conducted in Cape Town and George and subsequently through governmental department presentations and review processes.

The Response Strategy and Action Plan

The response strategy and action plan aims to strengthen the province's resilience to climate change and its adaptive capacity, particularly in vulnerable economic sectors and communities. It further aims to maintain the Western Cape's status as a relatively low greenhouse gas emitter by reducing the provincial carbon footprint even in the face of economic growth.

The action plan and strategy identifies water as a significant risk factor when considering climate change impacts, risk and vulnerability. Establishing a cohesive water supply and infrastructure management programme that integrates climate risks is a cornerstone of the response strategy and action plan.

The response strategy and action plan is built on the following prioritised programmes:

- ***An integrated water supply and infrastructure management programme that integrates climate impacts and risks*** – researching the cost benefit of irrigation, increasing water efficiency including through pricing strategies, establishing uninterrupted water conservancy targets, systems maintenance and repairs and establishing the ecological reserve

- ***Establishing clear links between land stewardship, livelihoods and the economy –*** effective land use and land care; protection, maintenance and enhancement of natural resources; strengthening vulnerable communities and protecting livelihoods through targeted research; maintaining diversity in the economy; integrating climate risks into development planning.

- ***Establishing a focused climate change research and weather information programme***

- ***Reducing the Provincial carbon footprint –*** energy efficiency, development of renewable and alternate sustainable energy resources, effective waste management strategies and cleaner fuel programmes for households and transport.

A supporting communications strategy

The strategy and actions implemented will only be effective if supported by an integrated communications strategy that will create awareness and understanding, drive prioritised change and support government policy decisions – some of which may be unpopular. Education and training for specific government departments and sectors, stakeholder engagement and targeted communication and awareness campaigns are central to the

communications strategy and are developed to support the key programmes identified as cornerstones to the Western Cape's response to climate change. A critical principle identified is the need to raise awareness levels in and to educate the province's youth – particularly given the timeframe and lead-in time challenges climate change presents us with.

A legislative review

The legal framework review examines the relevant environmental and social administrative legislation in which climate change and related issues operate in the province and in South Africa. An important legal review outcome is that the provincial Climate Change Response Strategy and Action Plan is not necessarily legally a policy. However, it does constitute a deliverable in that stakeholders have been informed and consulted in the development of the strategy and as such have a legal right and legitimate expectation to expect performance from the government of the Western Cape.

Climate change impacts and risks also give cause to consider the implementation of certain pieces of legislation that provide for action but which have not as yet been enacted. The Water Act, for example, provides for the implementation of the ecological reserve, which has not yet been enforced but which is certainly necessary given potential climate risks.

Funding mitigation and adaptation

A range of options are available in the international community that aim to support reduction of greenhouse gas emissions in developing countries such as South Africa - such as the Clean Development Mechanism (CDM). Other options support adaptation-based strategies and responses, such as research and implementation programmes through the United Nations Framework Convention for Climate Change (UNFCCC) Adaptation Fund.

The risk, however, resides at home and local leadership and financed response is critical if the province is to strengthen resilience and enhance adaptive capacity. Government owns significant amounts of the provincial infrastructure – some of which is extremely vulnerable to climate change at a high cost. Treasury has a key role to play in ensuring that budget allocations are appropriate and that these are considered, given the cross-sectoral nature of climate change. In any event, applications for UNFCCC funding can only be successful where supporting research and accurate information underpin the application. Certainly a partnership-based approach to funding is identified as a critical success factor.

Challenges, conclusions and key recommendations

The analysis, research and review work conducted in the 2005 Status Quo Review work and in 2006 / 2007 in developing this response strategy and action plan points clearly to the need for a response strategy that mitigates risk, reduces vulnerability and strengthens the province's capacity to adapt to climate change while simultaneously reducing the provincial carbon footprint.

A number of challenges exist when considering the implementation of a climate change response strategy and action plan for the province. A significant challenge lies in examination of appropriate and facilitative ***institutional arrangements*** required for effective implementation. Climate change is cross-sectoral by nature and is not restrained in any way by human imposed constraints such as linear government functions. A cohesive water programme, for example, requires provincial ownership, Department of Water Affairs and Forestry (DWAF) ownership and participation and then significant involvement by other departments such as agriculture. DWAF does not, however, have a provincial function and

although there are structures in place such as the Provincial Water Liaison Committee, accountability is not altogether clearly established.

A number of the conclusions are inherent in the response strategy and action plan. However, the province and South Africa will need to give careful consideration as to how the institutional arrangements are best structured to allow for the realization of sustainable development goals while dealing with the negative and positive impacts of climate change on achieving these. Both climate change and sustainable development – which indeed are intertwined – give rise to contemplation of the problems of inequality and poverty. When considering these against the environmental challenge inherent in the climate change scenario it may appear that the latter is not important – but to quote Amartya Sen, Nobel economics laureate and philosopher who visited South Africa in April 2007 to deliver a lecture on poverty, war and peace, "*It seems (to me) that the main challenge for a human being is how to take note of each of these major issues without putting them in a horse race with each other".*[4]

[4] As quoted in the Sunday Independent, 29 April 2007.

The Action Plan

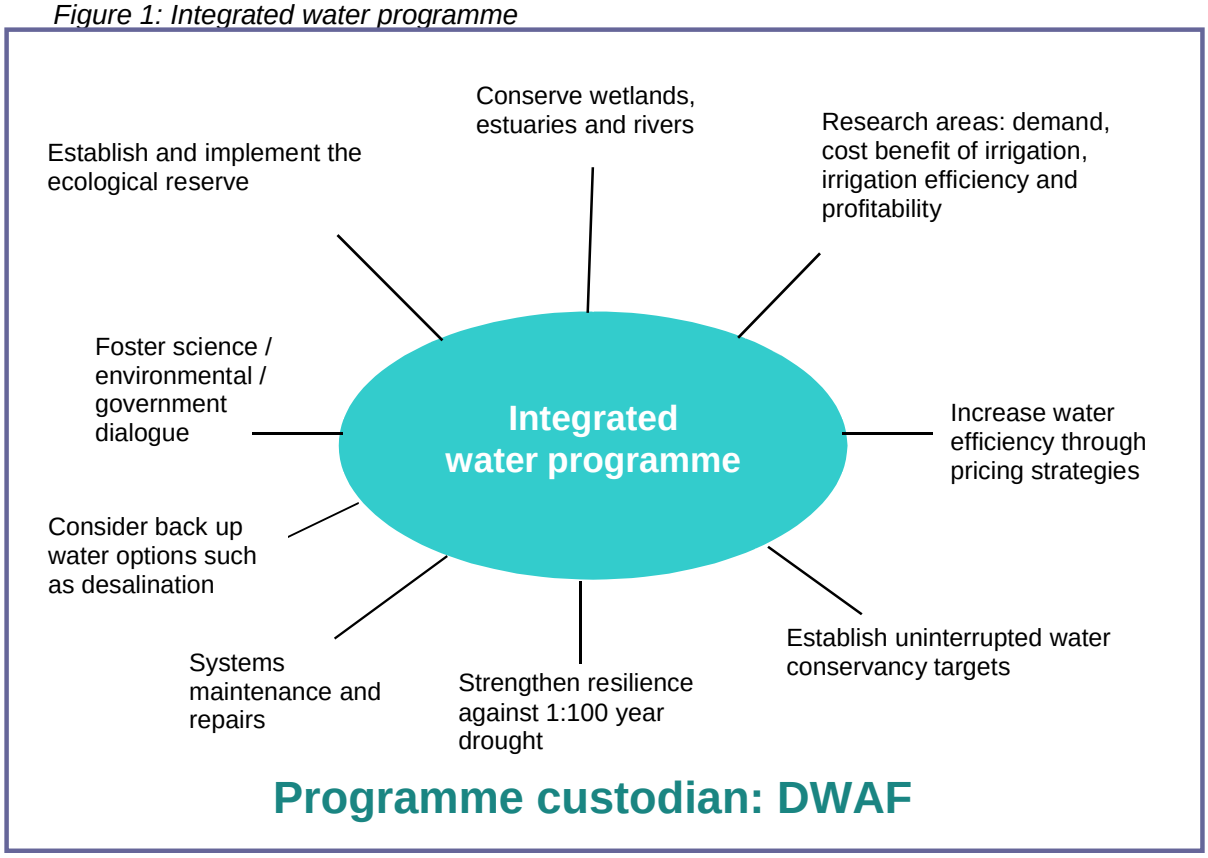
The Western Cape's Climate Change Action Plan is based on a set of integrated cross-sectoral planning and implementation programmes. These programmes include both mitigation and adaptation responses, and are outcomes based:

1 Adaptation response strategy and programmes
1 Integrated Water Management Programme
2 Climate change, weather research and information programme
3 Land stewardship and Livelihoods Programme
2 Mitigation response strategy and programmes
4 Energy, transport, waste and air quality management programme

Key outcome # 1

Establish a cohesive Water Supply and Infrastructure Management Programme that integrates climate impacts and risks

Figure 1: Integrated water programme

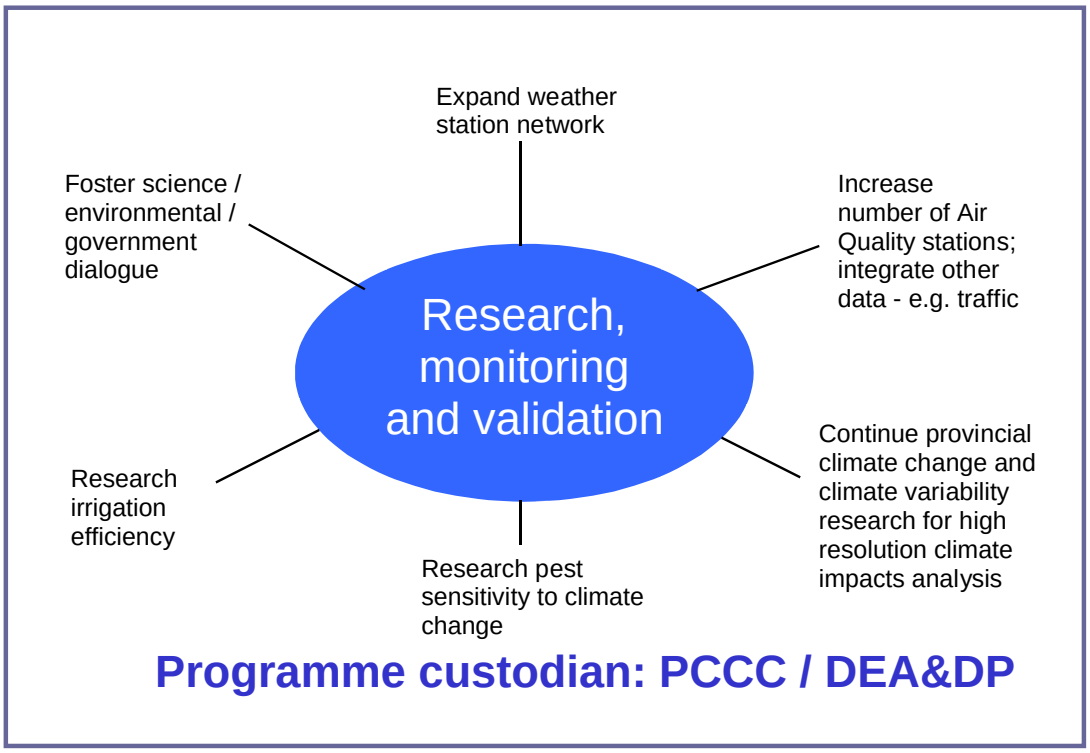


Source: OneWorld Sustainable Investments 2007

Key outcome # 2

Establish a focused climate change research and weather information programme

Figure 2: A focused climate change research and weather information programme

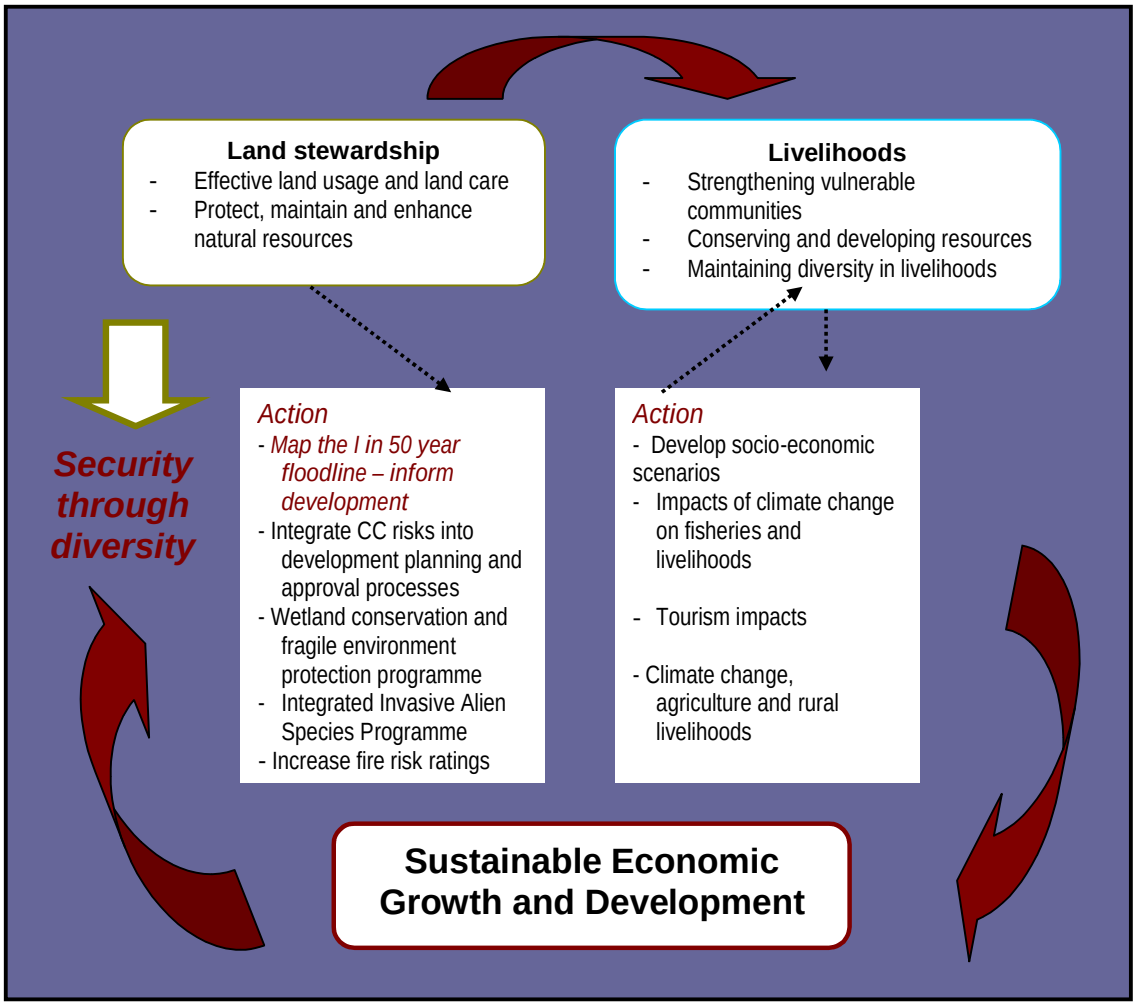


Source: OneWorld Sustainable Investments 2007

Key outcome # 3

Establish clear linkages between land stewardship, livelihoods and the economy

Figure 3: Linking land stewardship, livelihoods and the economy

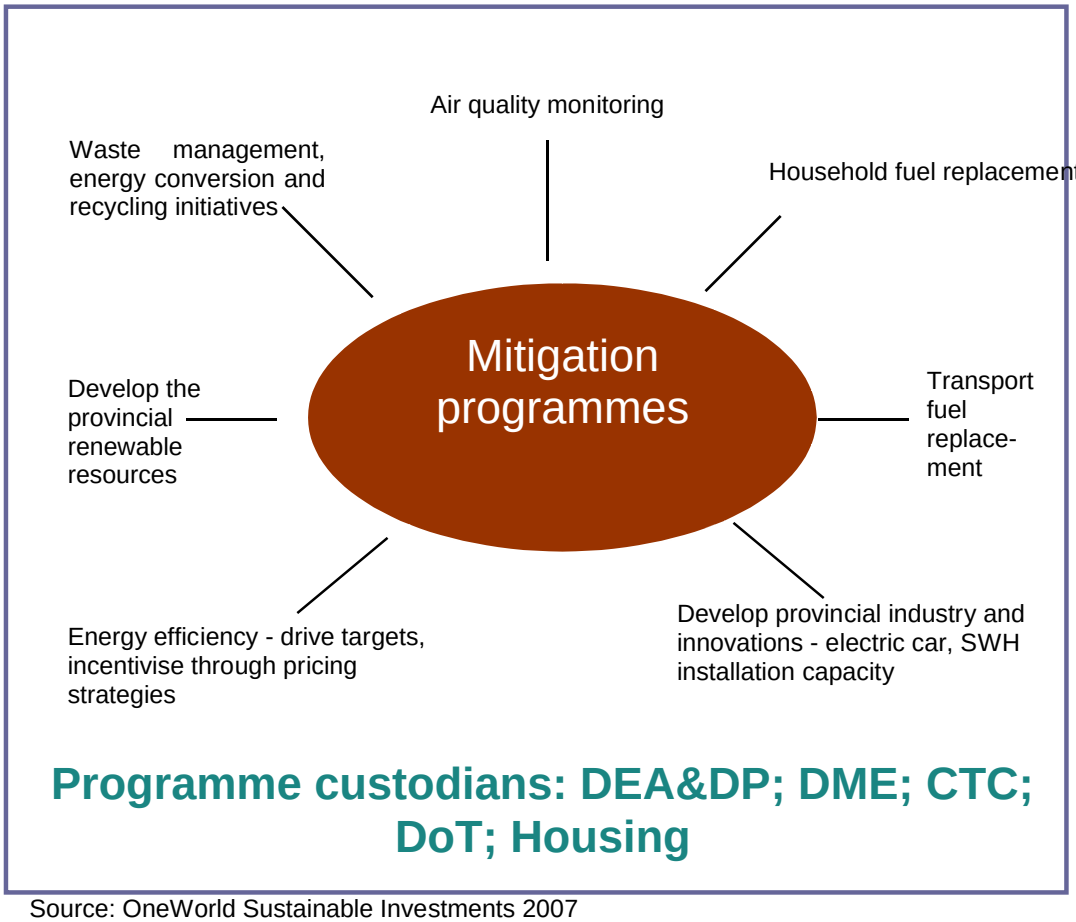


Source: OneWorld Sustainable Investments 2007

Key outcome # 4

Reduce our carbon footprint

Figure 4: Reducing our carbon footprint



Source: OneWorld Sustainable Investments 2007

Part 1

The Western Cape Climate Change Strategy and Action Plan

The strategy

Introduction

In August 2003, South Africa became a signatory to the Kyoto Protocol (KP), thus recognising the significance of global climate change and allowing this country to avail itself of emerging opportunities. Since the ratification of KP in 2005, climate change has increasingly become recognised as a major challenge to the global community. The fundamental question now is not whether our climate will change but rather when, where and by how much.

Recognising this province's particular vulnerability, the Western Cape government conducted a study on the "Status Quo, Vulnerability and Adaptation Assessment of the Physical and Socio-economic Effects of Climate Change in the Western Cape" (Status Quo Review) in 2005.

The issue for governments, business and the community is efficient **adaptation and mitigation planning** – what must be done now and in the future to minimise the extent and negative impacts of climate change, and also to capitalise on possible opportunities arising from those changes. The outcomes of the Status Quo Review pointed strongly to the need for effective planning and immediate action in this province.

This Strategy demonstrates government's leadership in responding to climate change. It promotes strategic policies and actions, natural resource and land use planning based on a risk-management approach and aims to foster a culture of innovation to capture opportunities. The Strategy is aligned with the goals established in the Sustainable Development Strategy for the Western Cape.

The Strategy has four components:

- Strategic Setting – the current context and high-level drivers for action
- Goals and Guiding Principles
- The Action Plan – outlining the wide range of actions for Government to both reduce greenhouse gas emissions (mitigation) and to facilitate an adaptive response to the impacts of climate change (adaptation)
- Review.

The Strategy aims to ensure that the Western Cape plans for the associated possible adverse impacts of climate change, manages our greenhouse gas emissions, contributes to a national strategy and, at the same time, is well positioned to take advantage of the opportunities associated with our changing climate.

Strategic setting

Our climate is changing

Many of our human and natural systems are strongly influenced by climate. Climate can influence productivity and reliability of supply – for example of water – and there is an expectation that our cities and infrastructure will cope with severe weather events efficiently and safely. There is also an expectation that socio-economic development should be fast-tracked, often with little regard for the impacts of climate change.

There is now general international scientific agreement that there is a discernible human influence on global climate (IPCC, 2007). Climate change is not just about a simple trend toward global warming. The knock-on effects of the increasing temperature of the lower atmosphere will impact upon all aspects of the physical environment, influencing rainfall patterns, wind, sea level, ecosystem processes and the frequency of severe weather events.

Climate change is a scientific issue and event. Responding to climate change however is far more about economic empowerment and strengthening resilience at a social, economic and ecological level.

The best available scientific information further indicates that some degree of climate change is inevitable – a large volume of greenhouse gases have already been emitted into the atmosphere *and* there is a strong continued growth in global emissions. The Status Quo Review and the analysis conducted as a basis to developing this Strategy identifies the range of natural, productive and economic systems that will be impacted by climate change.

The extent of the change is difficult to assess and predict on a regional basis, but what is clear is that the global climate is changing, that the rate of change is accelerating and that these changes will have an increasingly significant impact on the Western Cape's environment, businesses and communities.

Key issues in decision-making in response to climate change: Adaptation and mitigation

There are numerous ways to respond to the threat of climate change, presenting a wide range of possible actions. Broadly, these responses can be categorised into two main types of climate change response: we can either adapt our behaviour by accepting that our climate IS changing (adaptation responses), and/or we can invest in decarbonisation – i.e. mitigate through making a direct contribution to decelerating the rate of climate change (mitigation responses).

Mitigation responses and strategies are those that aim to reduce (either globally or within a country) the amounts of greenhouse gas emissions (GHGs) that are currently driving climate change. Since carbon dioxide (CO_2) is the largest component of GHGs, countries, cities and individuals measure their contribution to GHG emissions (and hence climate change) through measuring their 'carbon footprint'.

The IPCC Third Assessment Report (TAR) explains adaptation (IPCC 2001) as follows: Human and natural systems tend to adapt autonomously to gradual change and to change in variability. Human systems can also plan and implement adaptation strategies in an effort to reduce

potential vulnerability or exploit emerging opportunities even further. Facilitative adaptation responses are those government actions that "*allow households, companies and lower authorities to adapt better, that is, to make (for example) appropriate planning decisions…"*. Facilitative adaptation is also known as "***enhancing adaptive capacity***".

Adaptive capacity

Adaptive capacity is the ability of a system to adjust to climate change, including climate variability and extremes, to moderate potential damages and to take advantage of opportunities or to cope with the consequences (UNFCCC 1995). Adaptive capacity varies significantly from system to system, sector to sector and region to region. This means that it is critically important, in any assessment of adaptation, to identify immediately who is adapting to what.

The determinants of adaptive capacity (Smit *et al* 2001) are:

- economic resources
- technology
- information and skills
- infrastructure
- institutions
- equality issues.

It is generally accepted that communities and countries with the least resources have the least capacity to adapt and are thus the most vulnerable (Alberini *et al* 2006).

The decision to invest in adaptive capacity requires a consideration of costs, anticipated benefits and payoffs of a decision measured against the time profile of those investment flows. Decision-makers must decide between irreversible short-run investments in adaptive capacity, which may or may not be required in the end, and the potential long-term benefits of that investment. The extent of these benefits is dependent on the rate and character of climate change.

The **Risk and Vulnerability Assessments** conducted on each of the prioritised sectors and systems (see below) show us that the different systems have varying levels of intrinsic adaptive capacity. The capacity of a system to respond depends on its options for adaptation and the resources available for a response. Also, there is a wide range of responses available in responding to the threat of climate change, as summarised in the United Nations Environment Programme[5].

Responses to climate change: International and national trends

The Kyoto Protocol (KP) entered into force in February 2005 and the European Emissions Trading Scheme (ETS) commenced in January 2006. The flexible economic mechanisms such as the Clean Development Mechanism (CDM) provided for in the KP have seen considerable investment in the developing world in clean technology and renewable energy projects, thus assisting countries of the developed world to meet their emission reduction targets whilst creating opportunities for the developing world.

There has been an increasing focus in the international community on assisting the countries of the developing world to strengthen their adaptive capacity in response to the impacts of climate

[5] JF Feenstra, I.Burton, JB Smith and RSJ Tol 2003, *Handbook on Methods for Climate Change Impacts Assessment and Adaptation Strategies,* Institute for Environmental Studies: Amsterdam

change. The much-publicised Stern Report, published by Sir Nicholas Stern in the United Kingdom in 2006 on behalf of the UK government, is a leading international example. Some of the report's key findings are summarised below:

The scientific evidence of global climate change is overwhelming. Climate change will affect the basics of life: water, health, food production and the environment - and the poorest countries will be the hardest hit. The report estimates that a 'business as usual' approach to climate change will cost as much as between 5 and 20% of global GDP every year and on that basis recommends that greenhouse gas emission reduction targets should be set at 25% below current levels by 2050 to mitigate this cost. It further recommends that the development of poor countries **should not be compromised by developed world initiatives to reduce GHG emissions.**

The Review suggests an international framework that should include the following features:

- support for emissions trading
- support, cooperation and coordination regarding clean technologies
- increased budgets for research and development
- measures to reduce deforestation
- support for adaptation measures, particularly in poorer countries.

The UK Department for International Development (DFID) will be designing and implementing a five-year climate change support programme (of GBP 5 million) in 2007 in the SADC region. The programme is likely to be adaptation focused.

On a national level, South Africa has a climate change strategy and a functioning National Climate Change Committee (NCCC) on which the Western Cape is represented. South Africa is an active participant in annual meetings of the United Nations Framework Convention on Climate Change (UNFCCC) and is party to the discussions currently underway as to whether or not the developing world countries that are signatories to the KP should be allocated emission reduction targets post 2012.

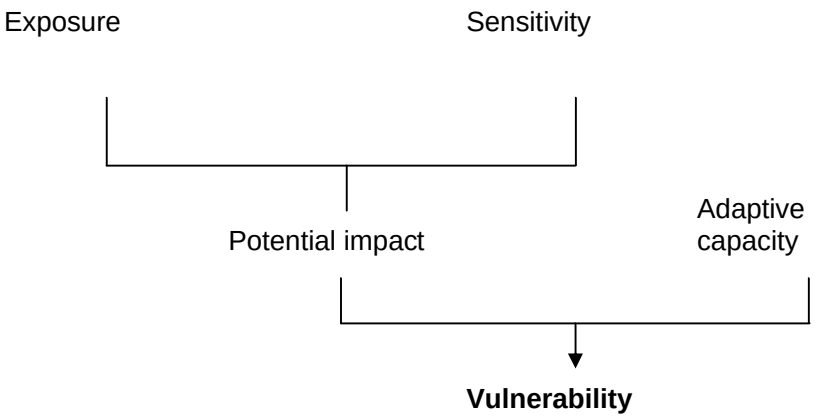
The Western Cape is the first province in South Africa to develop a response-based strategy and action plan (although the Durban Municipality has done considerable work in developing an action plan and response strategy). The Western Cape strategy and action plan is the only regionally-based response of this nature to date on the African continent. Many European, South American, Mediterranean and island based countries; regions and (in some cases) cities have developed climate change response strategies. Some have gone as far as to develop action plans.

The Western Cape's Climate Change Vulnerability and Risk

In order to assess the Western Cape's climate change vulnerability, the project team examined a set of key questions, i.e. *What is climate change? What climate change effects can the Western Cape expect? How vulnerable are the sectors and resources of the Western Cape to climate change?*

Climate change effects are dealt with in the next section of this report. Vulnerability can be defined as the function of exposure to climate change, the sensitivity to change and the capacity of natural and human systems to adapt to that change. In other words, vulnerability is measured by assessing the exposure of a particular system to climate change (i.e. how much will the sector be exposed to climate change) and the sector's sensitivity (i.e. how much will the system react to climate change). This equation gives the *potential impac*t of climate change on the system. However, some systems have some ability to adapt to climate change effects – called *adaptive capacity.* Vulnerability of the system is assessed by ascertaining the potential impact of climate change on its adaptive capacity. This is illustrated in Figure 5.

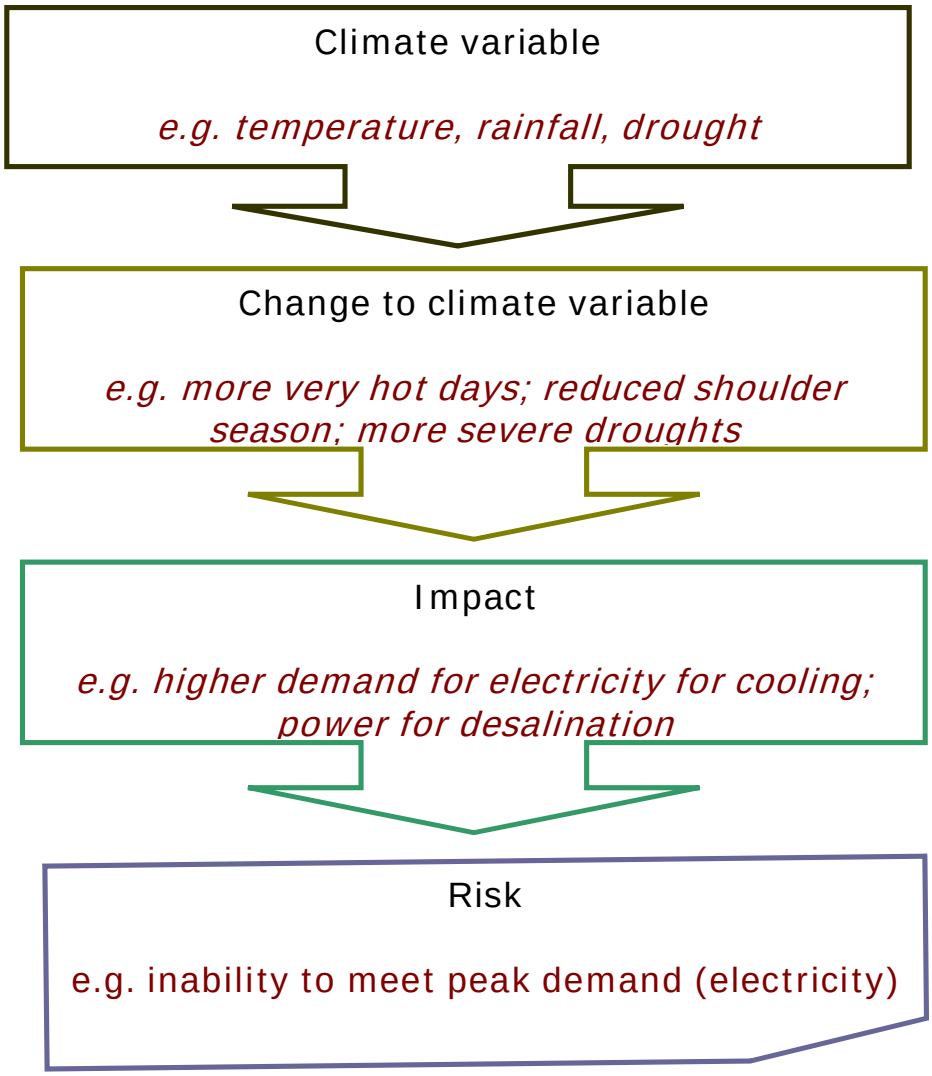
Figure 5: Vulnerability and its components (Source: D Schroter and the ATEAM Consortium, 2004)



Source: Adapted from D. Schroter and the ATEAM Consortium 2004. *Global change vulnerability – assessing the European human-environment system.* Potsdam Institute for Climate Impact Research. From *Climate Change Risk and Vulnerability – Final Report 2005:* Australian Greenhouse Office, p. ix

Figure 6 shows the links between climate change and risk. Assessing climate change, risk and vulnerability is central to the development of a Western Cape Response Strategy and Action Plan.

Figure 6: Understanding the links between climate change and risk: an energy sector example



Source: OneWorld Sustainable Investments 2007

Risk is evaluated using the formula:

The likelihood of occurrence multiplied by the consequence (impact)

Vulnerable resources, sectors and systems of the Western Cape

Those systems that are highly exposed, sensitive to change and less able to adapt are vulnerable. Vulnerable resources, systems and sectors of the Western Cape that have been identified as priorities for this strategy can be seen in Table 1.

Table 1: Vulnerable resources, sectors and systems of the Western Cape

Resource, Sector or System	**Focus**
Natural resources and systems	Biodiversity, water, coastal and marine systems and resources
The economic sector	Agriculture, fisheries, tourism
Infrastructure and economic resources; extreme events	Energy, transport, air quality, health; risk in relation to extreme events; disaster management
Livelihoods, adaptation and extreme events	Adaptation to climate impacts; strengthening adaptive capacity; disaster management responses

The socio-economics of the Western Cape and the impacts of climate change

The socio-economic impacts of climate change are poorly understood, and especially so on a regional level. Uncertainties in climate models coupled with uncertainties of how socio-economic systems operate leave a large margin for error in the results. A sole reliance on the traditional economic tools developed for prediction and control become less feasible when dealing with increasingly interconnected and random systems such as a local economy. The results from current economic modelling approaches as well as integrated assessment techniques need to be interpreted with caution when local response strategies are designed. Economies are in fact complex and often very dynamic systems, which puts a focus not only on the economic techniques used to analyse and predict the economic consequences of climate change impacts (see Turpie *et al*. 2004), but also, more strongly, on the context wherein these economies operate, and their geographical locations and historic trends. The measurement and analysis of complex systems, as well as 'trained common sense', would need to dictate approaches to real-world response strategies and action plans. The focus in a response strategy and action plan would therefore shift from impact-pathways and prediction to an analysis of resilience to change.

Until recently (see Box 1 below), estimating the costs and benefits of such impacts were even less well understood, and several attempts have been made to quantify the expected damages of a doubling of carbon dioxide in the atmosphere and the expected costs of controlling the release of greenhouse gases on international and national scales world-wide. Although further research on the socio-economic impacts of climate change will continue to shed more light on the expected economic costs of climate change and the benefits of dealing with the problem, information available to Western Cape policy makers is only indicative and leaves decision-makers in no position to steer towards more optimal economic choices.

This is not as major a problem as it may seem. Most impact pathway models and economic damage cost assessments do not take account of human adaptive behaviour, with some notable exceptions. Counterfactual ('what if') scenario models often fall short in evaluating the realism or desirability of the levels and types of adaptation (Tol 2005). A climate change response strategy and action plan that is focussed on adaptation while at the same time reducing our carbon footprint (thus taking mitigating action) would have to rely on an alternative, more realistic approach. This report will highlight the components of such an approach[6].

Box 1: The Stern review – estimating the costs of climate impacts

The Stern Review

Sir Nicholas Stern, UK Economist and author of the renowned "Stern Review: The Economics of Climate Change", believes that the costs of adaptation and mitigation action to stem the flow of carbon-dioxide emissions are not incompatible with the desire of business and governments to continue to develop and grow their economies. He goes on to quantify the cost of intervention as being 1% of global GDP ***as against a 5% knock to global GDP as a cost of inaction.***

The Stern report takes a rather extreme ethical viewpoint on intergenerational equity, which means that the welfare of far-off generations has the same importance as the welfare of present or near-future generations. This is achieved through the use of a near zero discount rate. According to Stern, we should be willing to pay up to 20% of present-day consumption annually (a 15% reduction amounts to a total of $7 trillion world wide, or 35 times South Africa's GDP) to save damages. The report implies a willingness to internalise an average cost of carbon of $311/tC – that is a potential unmitigated carbon damage liability of ZAR 225 billion for South Africa (calculated at 380,000 Gg CO_2 per annum) under a global carbon tax or global cap-and-trade system[7]. Alternatively, South Africa could pay for adaptation, calculated conservatively using Stern's assumptions on the costs of controlling GHG at roughly ZAR 12 billion per annum.[8]

The Stern report further argues that action could have a real economic and business upside, saying that low carbon development could spur major technological change – driving an era of innovation that may in fact stimulate economic growth. There are examples of such innovation in the Western Cape that impact on commercialisation and selling potential.

"The report is contentious. It is based on damage cost estimates which are on the extreme high side in economic literature, due to the use of a near zero discount rate, a position that needs a great deal more justification. It is also based on an economic stance on the costs of dealing with greenhouse gases" Dr Martin De Wit, Resource Economist, email

Despite the shortcomings in socio-economic impact assessment models, it is generally accepted that water availability, agriculture and human health will be most directly impacted on by climatic variability (DEA&DP, 2005). Extreme events, however, might have wider socio-economic impacts on sectors such as infrastructure and insurance. A preliminary high-level analysis on the anticipated socio-economic impacts of climatic changes was done in the "Status quo, vulnerability and adaptation assessment report" brought out by the Provincial government of the Western Cape in 2005 (DEADP, 2005). Table 2 reflects the possible impacts for the Western Cape. The importance of this work is not in the first instance to inform more exact levels of impacts, but to provide a first order prioritization of an action plan, to focus on the adaptive capacity of appropriate socio-economic systems and to start engaging with the right stakeholders and communities.

The types of sectoral impacts that have been described in climate change literature such as the IPCC's Third Assessment Report (IPCC 2001) and the South African Country Studies on Climate Change are listed in an abridged version in Table 2.

Table 2: Typical climate change impacts on economic sectors.

Sector	**Linkages and Impacts**
Agriculture, fishing	Change in production
Manufacturing	Change in processing of primary products (volume, quality)

[6] For further background the interested reader is referred to UNFCCC (2005), Burton et al 2004, Tol 2005, and the ongoing Assessments of Impacts and Adaptations to Climate Change (AIACC) projects.

[7] Figures quoted are based on gradual climatic change and are valid estimates unless one takes the view that there is a serious probability of an extreme disaster in the nearer future. We have no robust statements on this for the Western Cape (De Wit, email).

[8] De Wit, personal comm.. 2007

	New markets (climate control, sea defence, water conservation and supply)
	Government policies (carbon, fuel taxes)
	Customer preferences
Tourism	Change in tourist numbers due to temperatures and precipitation
	Sea-level rise and beach degradation
	Reduced stream-flow and water-based recreation
Finance and investment	Insurance for weather-events
	Banks, asset managers and underlying secured assets, investments
Transport, communication and trade	Temperature, precipitation and physical infrastructure
	Temperature, precipitation and travel demand, accidents
	Trade and communication and volumes/quality of production
Construction	Sea level rise and properties, rehabilitation of degraded bathing beaches

Source: DEADP (2005), based on IPCC (2001), Kiker (1999).

Risk and Vulnerability Assessments of vulnerable sectors and resources of the Western Cape

In order to ascertain the vulnerability of each of the sectors and resources identified, a *Risk and Vulnerability Assessment* was carried out on each one. These assessments are summarized in the following pages. Each sector or resource was assessed in terms of its exposure and sensitivity to climate change, as well as its adaptive capacity, any adverse implications foreseen, and, finally, its potential to benefit (where applicable).

Natural Resources

Water Resources

Increased evaporation and possible decreases in rainfall in many parts of the province will adversely affect water supply, agriculture and the survival of key species. Water quality may also be affected by increased soil erosion.

Risk and vulnerability assessment – Water: (a) Drought

Impact of climate change	*Risks and vulnerability aspects of the sector/resource*
Exposure	The Western Cape is subject to variation in rainfall such that a sequence of below-median rainfalls may occur, resulting in a drop in the yield of water supply systems and general water shortages (drought). Under climate change, the western parts of the Western Cape are likely to become drier and droughts more frequent. Where a water supply is shared, agriculture has the lowest assurance of supply. Environmental water allocation has the lowest priority *during a drought* and is therefore the first to be appropriated for economic and social requirements.
Sensitivity	Priority of water allocation for the agricultural sector: the exceedence of assurance of supply is as low as the 60^{th} to 70^{th} percentile level (failure can occur once in every three years). Extended periods of low agricultural production can force farmers off the land. Drought amplifies impacts of pollution, invasive alien plants and inappropriate land management on environmental capital (wetlands, rivers, estuaries and groundwater).
Adaptive capacity	Water supply systems need to be robust and new/alternative sources of supply need to be found. Increased skill from water managers is needed and long-term water projections are required. The farming community can adapt to some extent by increasing water conservation measures. Aquatic ecosystems like wetlands and estuaries are quite resilient if not stressed too severely for too long; conservation planning and management

	measures would help to build resilience.
Adverse implications	Over-exploitation of groundwater can result in permanent damage to aquifers and yield capacity through sliming[9] and/or seawater intrusion. Once contamination has occurred, it is very difficult to reverse. Water-dependent production systems are forced to cut back on production, resulting in a decline in economic performance. Significant declines in production in the agricultural sector can be expected, with loss of income down the value chain, and an increase in food prices, particularly harming poor people. Increased risk of wildfires and severe plantation forestry losses. Environmental capital is at risk. Declining inflows to wetlands and estuaries causes change to ecosystems functioning there. Significant long-term damage can occur.
Potential to benefit	

[Source: A. Chapman, 2007]

Risk and vulnerability assessment – Water: (b) Flooding

Impact of climate change	*Risks and vulnerability aspects of the sector/resource*
Exposure	South-western and southern coastal areas of the Western Cape experience occasional flooding produced by cut-off low pressure weather systems, which are likely to become more frequent with climate change. Human habitation and infrastructure in low-lying areas in the southern coastal regions from the Cape Flats to Plettenberg Bay are vulnerable to inundation and physical damage from fast-flowing water. Vulnerability of municipal infrastructure needs to be mapped as a matter of priority.
Sensitivity	Informal settlements in low-lying flood-prone land are particularly vulnerable. Vulnerable infrastructure includes: bridges and culverts, roads and railway lines, powerlines, pipelines across rivers, low-lying sewage works, schools and clinics sited inappropriately. Communities dependent on a few roads for access are vulnerable, as well as those that depend on infrastructure that crosses flood-prone land (e.g. farms in the Overberg and Agulhas Plain).
Adaptive capacity	Building of infrastructure in flood-prone areas needs to be prevented, or new buildings should accommodate flood size (the 1:50 flood). Existing infrastructure should be moved or rebuilt. Human settlement needs to be prevented, and where existing, alternative settlement areas provided. Conservation planning is essential to protect (and promote faster recovery of) riverine and estuarine assets.
Adverse implications	Tourism in areas dependent on road infrastructure (e.g. Knysna, Plettenberg Bay) may be affected. These towns are also vulnerable to damage to water supply infrastructure. Industrial businesses near flood-prone land are vulnerable. Flood events cause severe scouring of river banks, and ecosystems may take years to recover. Floods in 2003, 2004, 2005 and 2006 caused more than R900 million in damage.
Potential to benefit	

[9] Sliming: Bio-fouling that occurs when bacteria and other microbes respond to dropping water levels, and the subsequent change from a reducing environment to an oxidizing one when these organisms come into contact with air.

[Source: A. Chapman, 2007]

Biodiversity

The risks and vulnerability of this sector are shown in the form of a table reflecting the various regions of the Western Cape.

Risk and vulnerability assessment

Regions	Political	Climate change impacts
South West	Land tenure and land reform; land use change; population influx into the Western Cape	Relevant issues are water quality and yield; invasive alien species; loss of land to agriculture; maintenance of biodiversity; disaster and risk management and assessment (drought, flood and fire). **Climate change, variability and extreme events**
North-West	Land tenure and land reform, land use change	The key issues are invasive alien species; loss of land to agriculture; maintenance of biodiversity; disaster and risk management and assessment (drought). **Climate change, variability and extreme events**
South Coast	Land use change	Issues here relate to invasive alien species; loss of land to agriculture; water yield and quality; maintenance of biodiversity; disaster and risk management and assessment (drought, flood and fire). **Climate change, variability and extreme events**
Karoo	Land tenure and land reform; land use change	Issues focus on climate variability; disaster and risk management and assessment (drought). **Climate change, variability and extreme events**

[Source: G. Midgley, 2007]

Coastal and Marine systems and resources

Risk and vulnerability assessment

Impact of climate change	*Risks and vulnerability aspects of the sector/resource*
Exposure	Expected risks and vulnerabilities to climate change are (Hughes *et al*, 1991): increased exposure to extreme events (which might also increase in frequency or intensity), increased saltwater intrusion and raised groundwater tables, greater tidal influence, increased flooding (frequency and extent), and increased coastal erosion. Increase in storm activity and severity is likely to be a highly visible impact. Particularly vulnerable are Western Cape's 50 estuaries (five are highly important for biodiversity conservation), which are important feeding and nursery grounds for many shellfish, fish and bird species, and are economically important as fisheries. Most estuaries have been degraded, and climate change could greatly exacerbate existing threats. Increased storminess may critically affect salinity and closed/open estuary mouth status.
Sensitivity	Areas sensitive to flooding are (a): low-lying areas adjacent to some estuaries, tidal inlets, coastal wetlands and marinas; (b): sea walls, road and rail embankments built too close to the sea. Rocky shores will experience a landward movement of high-water lines. Sandy coastlines will experience some degree of erosion (20-80m depending on slope).

	Shoreline is sensitive to sediment supply and budgets (movement of sand and other sediment) and expected to be relatively sensitive to climate change. Sea level rise will impact on coastal ecology where developments are too close to high-water lines.
Adaptive capacity	Coastal protection/structures can be designed for new developments. Very little adaptive capacity for existing infrastructure and developed areas except costly upgrades and replacements. Natural areas: some adaptive capacity but only where there is a sediment 'surplus'. If undisturbed, natural ecosystem is expected to generally have good adaptive capacity. Halting coastal impact is both virtually impossible and may lead to other detrimental effects. Adaptive capacity lies mainly in planning and research: identify thresholds of dangerous change including sensitivity analyses; develop provincial vulnerability atlas/GIS for potential impacts/hotspots; determine coastal erosion and development setback lines; draw up shoreline management plans; design coastal protection/developments/structures to compensate for CC effects.
Adverse implications	Protection for shipping provided by breakwaters will be slightly reduced; more maintenance will be required. Existing problems of endangered and unwisely located revetments and sea walls that protect housing, promenades etc. will worsen considerably/beyond critical limits. Road/rail embankments too close to the sea may be structurally damaged by underscouring. Managed dunes providing protection will be reduced. Tidal pools, jetties and harbour walls will become less safe. Erosion of sandy beaches, altered conditions for estuaries, increased saltwater intrusion and raised groundwater tables in farming areas adjacent to estuaries/shorelines are other adverse implications.
Potential to benefit	Virtually none, apart from possible improvement of marine water quality in a few problematic areas. Impacts and potential to benefit for estuaries are complex, uncertain and need to be investigated.

[Source: A. Theron, 2007]

Economic sectors

Agriculture

Risk and vulnerability assessment – Agriculture

Impact of climate change	*Risks and vulnerability aspects of the sector/resource*
Exposure	Key climate changes: reduced annual rainfall, altered rainfall distribution, increased heat unit and decreased chill unit accumulation, heat stress. System impacts: reduced soil and water quality, increased risk of drought/flood/hail /frost, increases in weeds/pests/diseases. Impacts on crops and animals: reductions in yield, reproductive success and product quality. Highly exposed and vulnerable industries are those reliant on rainfall (small grains, rooibos tea, stock on western semi-arid rangelands), those which require significant chill units (apples, pears), industries currently situated in areas considered marginal for their requirements, especially industries in the semi-arid North-West and Swartland. Irrigated agriculture will be vulnerable under shortages of irrigation water. Intensively managed crops and animals in climate-controlled enclosures (poultry, greenhouse vegetables and flowers) will be moderately exposed.
Sensitivity	Industries dependent on rainfall for annual growth will show rapid yield responses to reductions in rainfall or lack of rainfall at critical times. Irrigated crops will be less sensitive provided there is sufficient water. Perennial crops will take longer to respond but will show carry-over effects from one season to the next and gradual decline with prolonged adverse conditions. Impacts of heat stress, pests and diseases will be rapid. Immediate benefits of elevated CO_2 on plant growth will partially mitigate negative responses to CC in productive areas, but reduce pasture and feed quality. Timeous implementation of

	available technologies for adaptation will significantly reduce sensitivity in most industries up to a threshold, whereafter adaptation will become less effective.
Adaptive capacity	A range of adaptation options is available, including adjusting production practices, increasing water use efficiency, changing the mix of cultivars or commodities (farming system), diversification of on- and off-farm income-generating activities, or adjusted marketing strategies. Adaptation responses are either *autonomous* (ongoing implementation of existing and new knowledge and technology by producers) or *facilitated* (the increase in adaptive capacity through actions taken at political and institutional level e.g. regional water and infrastructural planning). Resource-poor and technology-limited farmers and those on marginal land will struggle to adapt and will experience the worst economic impacts. Rainfed agriculture and high-chill pome fruit production have few adaptive options.
Adverse implications	Climate change impacts on productivity will affect regional and national food security, food prices, secondary and supportive industries and services, regional tourism, and thus gross regional product. Reduced household income and loss of jobs in areas highly dependent on agriculture will cause increasing hardship for regional communities and rural livelihoods and de-population through migration to larger towns and cities. Abandonment of farmland could lead to invasion by weeds with knock-on effects on biodiversity.
Potential to benefit	Better planning due to more accurate and reliable forecasts can increase productivity in "good years" and allow farmers to change their farming system in expected "bad years". Other benefits: development of more suitable new species and cultivars/breeds (e.g. indigenous), increased use of climate-control structures (hail/shade netting, greenhouses), improved resource use efficiency, better pest and disease control, capitalising on market pressures on competing industries and countries. Sheep farming in the eastern parts could benefit from more productive rangelands and reduced incidence and severity of frost. The Overberg and Garden Route regions could benefit from relocation of industries eastwards, and indigenous afforestation along the Garden Route with potential for new jobs and increasing incomes.

[Source: S.Midgley, 2007]

Fisheries

Risk and vulnerability assessment

Impact of climate change	*Risks and vulnerability aspects of the sector/resource*
Exposure	Key climate change effects: sea surface temperature (SST) change, stock decline, species change, adverse weather, circulation patterns, and recruitment. Highly vulnerable aspects are: sensitivity of recruitment success to circulation and SST; declining biomass of cold-water commercial species, compounded by over-fishing. A reduction in Catch per Unit of Effort (CPUE) is likely, compounded by poor effort management.
Sensitivity	Catch rates may decline sharply (compounded by slow management response) with potentially lower income, which will impact heavily on fishing communities. Technology lags in implementing necessary changes would hamper adaptation. Relocations are unlikely but if effected will be a highly sensitive issue. Fishing stocks and recruitment are not expected to respond quickly to climate change effects.
Adaptive capacity	Fishing stocks, biodiversity and ecosystems are likely to adapt very slowly to climate change. Colonisation of different species is likely. CPUE is not expected to compensate for climate changes, although the industry can adapt to stock and species shifts with medium to high investment in technological changes. Poorer fishing communities and those where fishing as a livelihood is entrenched will experience a heavy economic impact and are unlikely to be able to adapt. Ecosystem approach to fisheries could

	incorporate CC effects into fisheries management.
Adverse implications	Negative impact of climate change on stock biomass is high, especially as compounded by exploitation pressure. SST changes and other physical ecosystem drivers will have a critical impact on food chains and ecosystems. Effects of climate change on recruitment will be high, may lead to stock collapses when compounded by exploitation. Downward CPUE and sub-economic fishing operations are very likely. Fishing industry is highly vulnerable to job losses and loss of income. Stocks and species shifts will have serious impacts on economies of fisheries.
Potential to benefit	Potentials to benefit under climate change are few and uncertain. New commercial species may be associated with warmer water – leading to creation of new jobs but this will trade off with losses in other sectors. Relocation could result in improved wellbeing where new resources have developed.

[Source: D.Japp, 2007]

Tourism

Risk and vulnerability assessment

Impact of climate change	*Risks and vulnerability aspects of the sector/resource*
Exposure	Key climate change effects: The tourism sector is likely to be affected by increasing sea temperatures, rising sea levels and the related impacts on beaches and estuaries. Increasing adverse weather events such as floods will cause damage to tourism-related infrastructure (e.g. promenades and waterfront developments, beach resorts and facilities; coastal routes and attractions).
Sensitivity	Sensitivity will vary depending on the branch of tourism. Nature-based and eco-tourism industries are highly sensitive to climate change (for example, a shorter flowering season and variation in timing of flowering of wildflowers on the West Coast is likely). Many species are unable to migrate (e.g. quiver trees). Reduced water availability will affect the status of estuaries, while warmer temperatures will increase the incidence of algae blooms that kill fish and/or affect nursery conditions for fish and shellfish, with resultant loss of birdlife, or cessation of visiting patterns (e.g. Rietvlei, 2007) – impacting on eco-tourism. Increased incidence or recurrence of wildfires in areas of sensitive biodiversity (e.g. Table Mountain and the Cape Peninsula) would affect tourism to such areas (See also Water PESTLE and R&V). Tourism may be sensitive to extreme weather events such as heat waves and temperature increases. Climate change could impact on the profitability of tourism as increased temperatures will increase energy use (e.g. air conditioners and refrigeration). Approximately 50% of hotel energy consumption is attributable to air conditioning.
Adaptive capacity	Larger tourism operators and organisations have the flexibility and resources to adapt to climate change. Investment in infrastructure such as securing beaches and diversifying activity bases could assist. Energy efficiency – for example, the industry converting as far as possible to solar water heating and reducing reliance on air conditioners is critical.
Adverse implications	The tourism industry is of significant value to the Western Cape where the bulk of our tourists are foreign bringing significant spend in foreign exchange to the province. It is earmarked as a growth industry for the Western Cape, and the province has identified that most new jobs created will be in this sector. Activities linked to environmental assets drive a significant component of this income (examples include beaches, whale watching, kayaking, mountain hiking, bird watching), and the Cape Winelands are a significant tourist attraction. Climate impacts on these are likely to have adverse implications for employment and revenue, particularly for Cape Town and the Garden Route. A further implication for the Western Cape tourism is international response to climate change where mooted mitigation measures include Carbon taxes on long haul flights. This may encourage international tourists to seek closer holiday destinations.
Potential to benefit	Opportunities lie in preventative investments such as energy efficient tourist developments and hotels, and the reinforcement and protection of coastal infrastructure and facilities.

	Warmer weather might present other opportunities and activities.

[Source: B. Petrie, 2007]

Infrastructure and economic resources

Energy Infrastructure and Energy Services

Impact of climate change	*Risks and vulnerability aspects of the sector/resource*
Exposure	Key climate change effects: The current peak demand for centralised electricity in the Western Cape is for 3640 MW supplied by Eskom (3460 MW) and Steenbras Pumped Storage (180 MW). Local ESKOM supply is 1800MW installed capacity from the Koeberg Power Station and 420 MW of pumped Storage capacity at Palmiet, with the balance being imported from the coalfields of Mpumalanga. The country has a medium-term (10 year) deficit in power generation capacity. The bulk of existing non-electricity supply comes from liquid fuels for transport and wood-fuel and paraffin burning for household energy service needs, particularly in the peri-urban areas. Both of these contribute significantly to local emissions and to poor air quality (both ambient and indoor). Increasing temperature and heat waves will increase the demand for energy (air conditioners, refrigeration and water pumping / treatment) in the summer. Rainfall reduction will see an increase in demand for energy consumptive irrigation and crop spraying systems. Extreme weather events such as flooding and bushfires may increase the damage to energy infrastructure such as powerlines. Increased ambient temperatures will exacerbate the vulnerability of poorly maintained electricity distribution infrastructure to failure. Increased temperatures can also reduce transmission efficiency. Increased temperatures and wind velocity will exacerbate shack fires caused by unsafe paraffin usage. An increase in demand for energy results in an increase in contribution to global emissions as the province draws 92% of its electricity from coal. Lastly, water consumption for coal-fired electricity generation is 1.2 litre/kWh, which has had a negative impact elsewhere in SA and this cost may be reflected back to the Western Cape in future.
Sensitivity	Sensitivity is high in the western part of the Western Cape where peak demand is already stretched. The western part of the Western Cape is highly dependent on the Koeberg station and long HV transmission infrastructure, and, given that South Africa lacks sufficient reserve generation capacity, there is no margin available for maintenance, repairs and increased demand issues.
Adaptive capacity	Short-term capacity is limited as infrastructure changes require long lead-times. Longer term planning is possible but requires high capital investment. Natural gas is currently being explored off the West Coast of South Africa (Northern and Western Cape border); the project has an investor and developer and, depending on approval processes in government, is likely to yield the quickest form of new generation capacity in the region. Other possible grid-based investments exist in wind and wave power generation. Non-electrified localised energy sources exist in solar energy; domestic energy demand can be significantly reduced through large-scale introduction of SWH in the province. This would make a significant impact on peak demand. Demand side management could reduce energy demand by as much as 30% and is a short-term option. Energy efficiency targets could result in immediate impact of 10–15% reductions in demand. The Western Cape transmission network needs to be strengthened**.** Opportunities exist for accessing funding from the clean Development Mechanism (CDM**)** for clean energy project development (see CDM section in this report). Interestingly, the province has a high level of human capital with expertise in energy R&D and operations.

Adverse implications	Uninterrupted power supply is an essential service for the economy and for health, safety and households. Power outages (as experienced in 2006) can result in significant economic and social costs. The most significant social and economic costs are due to the unpredictability of access to energy (reliability of supply) and future costs (due to mitigation costs and escalating resource costs).
Potential to benefit	Adaptation planning is feasible and desirable – energy efficiency and renewable options such as thermal insulation and solar water heating in the short term, and cleaner locally-based power generation options (wind, bio-energy and natural gas) in the medium to long-term. These fit squarely within existing planning regimes (National Energy Strategy, Renewable Energy White Paper, Western Cape Integrated Energy Strategy). Significant local employment opportunities would arise from increased provincial energy service supply. Winter demand for energy could decrease in some regions.

[Source: B.Petrie & G.Morris, 2007]

Air Quality

Risk and vulnerability assessment

Impact of climate change	*Risks and vulnerability aspects of the sector/resource*
Exposure	Elevated temperatures due to climate change may result in increased levels of ambient ozone (a secondary air pollutant, not associated with the protective stratospheric ozone layer). Vehicle emissions have greatest impact on formation of ambient ozone – and need to be monitored closely. Sources of ozone are mainly urban, but effects downwind will be in rural areas, e.g. some adverse health effects and crop damage. Greater risk of fires because of increased wind velocity and temperature, resulting in higher levels of PM10[10] in certain areas.
Sensitivity	Increased respiratory problems, e.g. asthma, affecting especially the young, old and sick are likely. Certain vegetation is sensitive to elevated levels of air pollution. Increased land fills and urbanization are direct drivers on air quality (AQ) but inadequate AQ monitoring in the province means it is uncertain how development in certain areas will affect AQ. In Cape Town increased temperatures might result in fewer days when low level temperature inversions contribute to increased air pollution levels. Industry and development expansion must be based on new AQ measures and standards.
Adaptive capacity	Existing mitigating and adaptive projects must be followed through/monitored. New cleaner technologies could be employed and expanded. Cleaner heating/cooking fuels could be used instead of wood and paraffin. Alternative cleaner vehicle fuels could be used, although water (and perhaps CO_2) necessary for their production may be problematic. Car catalytic convertors are already in 37% of cars; regulations will ensure they are standard. New industry and development must meet new AQ measures & standards.
Adverse implications	Increased respiratory problems bring increased insurance and medical costs. AQ depends partly on growth/ development rates in urban areas. Possible scenarios for AQ under climate change are: (1) a small positive impact in Cape Town while other areas experience an adverse impact mainly due to increased development; (2) AQ could deteriorate everywhere in the province due to increased development and increasing ozone levels; or (3) AQ could improve due to warmer climate but a lower level inversion usually results in trapping of the pollutant layer. Stronger winds may result in the wider dispersion of air pollutants. Trends need to be monitored and managed accordingly.

[10] PM10 is the name given to particulate matter of 10 micrometres or less. Particulate matter consists of tiny particles (solid or liquid) suspended in a gas. PM10 is too small to be filtered out in breathing and lodges in the respiratory tract, bronchi and lungs causing various health problems.

Potential to benefit	Higher temperatures (and mitigation programmes) would mean less reliance on space heating, which could imply a reduction in emissions (mainly PM10) levels and lead to fewer fires in these areas. However it is likely that individual households will use the same amount of fuel for cooking and heating given that a cooked meal is relatively insensitive to room temperature. Possible improvement in AQ in large urban areas could improve quality of life and increase tourism (fewer brown haze days).

[Source : C.Fedorsky & B.Petrie, 2007]

Transport

Risk and vulnerability assessment

Impact of climate change	*Risks and vulnerability aspects of the sector/resource*
Exposure	Key climate change effects: Transport is responsible for 54% of the total energy use in the City of Cape Town and is a significant contributor to local pollution problems. The high consumption of petrol and diesel leads to high gaseous emissions. Although much of the problem is currently associated with Cape Town and environs, other areas of the province (for example the George area) are experiencing economic development accompanied by a growth in vehicle sales and numbers of cars on the road, which will result in a corresponding growth in vehicle-based emissions. The George Mobility Strategy will see the introduction of a new public transport system in the region. Urban growth and planning practices expose the province to increased transport emissions in instances where communities are located in areas that are not in close proximity to places of employment and leisure.
Sensitivity	Sensitivity to vehicle emissions is already high in the Cape Town and Winelands district municipal areas. Urban sprawl and location of townships far from employment areas in these districts as well as in the George areas result in longer, more emission-intensive daily commutes.
Adaptive capacity	The use of alternative fuels such as LPG[11], CNG[12] and biofuels[13] could lower transport emissions significantly, however short-term adaptive capacity is constrained by the inconsistent availability of these fuels. Planning for much-needed public transport infrastructure (both urban and inter-urban) can include climate change considerations – in particular emission reduction options. Global funding for the use of cleaner transport technologies is available for countries such as South Africa in the form of the Clean Development Mechanism (CDM).
Adverse implications	Transport services are critical to socio-economic development. Current poor service levels of public transport and/or lack of public transport infrastructure make mini bus taxis more convenient than scheduled buses, thus making it more difficult to manage and drive alternate fuel programmes in the transport sector. An increase in transport demand that is met by increased taxi services and not by emission controlled public transport services will have a negative environmental impact with adverse human health implications caused by local pollution events.
Potential to benefit	Adaptation planning is feasible – particularly given the already-identified need for improved transport services. A programme to control vehicle emissions and institute the use of cleaner fuels such as LPG, CNG and bio fuels could reduce the number of local pollution events. Improved public transport systems running on cleaner fuels would improve efficiency, reduce road congestion and delays, increase investment potential and improve air quality. The province stands to benefit from integrated urban and transport planning.

[11] LPG – Liquefied Petroleum Gas
[12] CNG – Compressed Natural Gas
[13] Biofuels – fuels made from plant biomass

[Source: B.Petrie, 2007]

Health

Risk and vulnerability assessment

Impact of climate change	*Risks and vulnerability aspects of the sector/resource*
Exposure	Key climate change effects: Human health is likely to be affected directly and indirectly by increasing temperatures, the frequency of heat waves and changing rainfall patterns. The reduction in availability of water as well as in the supply of clean potable water may lead to reduced levels of personal hygiene and an increase in related diseases. Population growth in urban areas coupled with the situation of less water may lead to an increase in the incidence of water-borne diseases, further impacted by deterioration of the quality of water sanitation. Higher temperatures will increase the quantities and spreading of invasive animal species, some of which impact directly on human health (e.g. Indian House Crows and rats). The population's immune systems may be further compromised by extremes (e.g. heat and cold) brought on by the symptoms of climate change. Climate change is seeing the introduction of new diseases such as avian ('bird') flu.
Sensitivity	Sensitivity is high in all regions in the Western Cape where temperatures are expected to rise and rainfall to decrease. The Working for Water programme is already trying to combat invasive species but many of these species are sensitive to climatic changes. Vector-borne diseases, food-borne diseases and temperature-related illnesses are likely to increase in the western part of the Western Cape in particular.
Adaptive capacity	The ability of the Western Cape's infrastructure to respond to quarantine and bio-security threats and to detect disease outbreaks through surveillance is improving but is not comprehensive enough to cope with the adverse effects of climate change. The health system does not have the financial capacity to mobilise health promotion campaigns required to educate the population on dealing with various effects, e.g. heat stress. The provincial health facilities are already stretched to capacity and there is a shortage of adequately and appropriately skilled staff. This is a particular issue in the case of new diseases spreading. Land use planning, building and settlement design and pest control measures have the capacity to moderate the influences on human health.
Adverse implications	Failure to deal with invasive species and the resultant human health impacts will have severe socio-economic impacts. This is similarly the case with water access and water quality. Loss of life and the impact on hospital and emergency services through extreme weather events is likely but not predictable. While there is an anticipated increase in the incidence of vector, water and food borne diseases, this need not be high if existing efforts in surveillance, quarantine and bio-security measures are improved and maintained. Some population groups are more vulnerable – particularly the elderly (heat stress) and low-income communities.
Potential to benefit	Adaptive responses are feasible and likely to constitute an extension of existing strategies and the facilitation of health campaigns.

[Source: B.Petrie, 2007]

Livelihoods

Risk and vulnerability assessment

Impact of climate change	*Risks and vulnerability aspects of the sector/resource*
Exposure	Key climate change effects: Livelihoods are exposed to climate change in terms of economic vulnerability (for example agriculture decline will result in rural job losses, impacting on rural livelihoods as well as in terms of direct exposure to the compounding effects of climate change, such as shack fire spread as a result of stronger prevailing winds).
Sensitivity	Livelihoods are particularly sensitive to extreme events. Vulnerable communities and infrastructure that for example exist on the floodline are particularly vulnerable to extreme weather events resulting in flooding. Increases in high pollution episodes have health implications with resultant livelihood impacts. This is a particular issue in poorer communities that live in high-density conditions and which burn pollutants for cooking and space heating.
Adaptive capacity	The most vulnerable communities are the poor who have low adaptive capacity – particularly given living location (floods, fires) and conditions and minimal economic resources to facilitate a change in these circumstances.
Adverse implications	Climate impacts on sectors of the economy (agriculture, tourism) are likely to have adverse implications for employment and revenue. Not responding will mean that rural populations that lose jobs because of a decline in agriculture or fisheries are likely to move to the urban areas, placing even greater strain on jobs, resources and infrastructure. Some of the possible climate response measures could have a negative impact on the poor unless carefully designed and implemented. Energy efficiency targets and related pricing strategies will negatively impact the poor unless tariff structures are designed to impact on high-end users
Potential to benefit	Benefits may be derived from jobs created through commercialising technologies, innovations and industries (such as solar water heating) as a result of responding to climate change. A strong focus on integrating climate risks into development planning can benefit the poor, for example building energy efficient houses will result in considerable savings on monthly household running costs, *viz.* energy and water bills. Improving emissions through fuel replacement programmes at a household level will contribute positively in reducing shack fires where households lose all their possessions. Effectively responding to climate change in the Western Cape requires a focus on economic empowerment.

[Source: B. Petrie, 2007]

Climate Change in the Western Cape

The full report on climate change in the Western Cape prepared by the Climate Science Analysis Group, University of Cape Town, appears in the Western Cape Climate Change Strategy and Action Plan Supplementary Report.

Recent modeling has indicated the expected climate changes for the Western Cape for the 2030 – 2045 period. The analysis undertaken by the Climate Science Analysis Group (CSAG) at the University of Cape Town has provided a set of robust statements for expected changes for this province.

The timeline parameter for the response strategy is the 2030-2045 period. 2030 is the earliest anchor year to which climate change projections can realistically be scaled back from global climate models, which look at 2045 and beyond. 2030 is also a time horizon within which policy, economic and business decisions can realistically be made.

Changes in rainfall and precipitation

Precipitation means any form of water (e.g. rain, snow, drizzle, etc.) that falls to the Earth's surface. Precipitation is forced by large-scale circulation yet significantly modulated by topography (for example the presence of mountain ranges). Historical change in the Western Cape shows a clear pattern of drying in western lowland regions, with a stable or wetter trend in the mountains. There is clear physical understanding for this.

Summary – precipitation

The estimates of historical changes in rainfall show significant change, and have a complex regional and seasonal pattern. A simple continuation of these trends into the future is not a necessary expectation, although there is qualitative agreement with the broader aspects of the projected future change (see below). The most notable change and the one likely to be of most concern is the western drying away from the mountains.

Note: Future projections are simply that: a projection. At high spatial resolutions there still remains significant uncertainty. There is greater confidence in the pattern of projected change than there is in the magnitude.

- In the far south-west of the province there is a general decrease in precipitation in all seasons. The decrease is strongest in early and mid-winter. These changes are likely to lead to an associated decrease in water availability.
- In the eastern coastal regions there are likely to be moderate increases in the early winter, with moderate decreases in late winter.
- In the interior arid zones to the north-east there are likely to be small increases in rainfall.
- The different projections show general agreement for a shorter winter rainfall season.

- The specific location of the boundaries between regions of stronger increases or decreases is a point of uncertainty. The western coastal mountains are one important feature that delineates a boundary.
- For the most part the spatial pattern of change in the number of raindays and the amount of rain per rainfall event mirrors that of the change in monthly totals, although the finer regional details show some exceptions.

Changes in Precipitation: Challenges to communities and livelihoods

Drier shoulder seasons (autumn and spring) threaten the Western Cape's deciduous fruit export sector, which needs the cooling period in autumn to produce export-quality fruit.
The heightened drying factor adds to the creation of conditions suitable for veld fires in spring, summer and autumn (especially when coupled with increased wind velocity and higher temperatures – see below). Veld fires threaten livelihoods, both directly (for example agriculture) and indirectly (for example tourism). When widespread, or when many veld fires occur simultaneously, they strain disaster management resources.

Figure 7 shows an increase in annual rainfall in the early and mid-20th century, with a decreasing trend since the 1980s, for one mountainous region. Note the severity of the drought during the 1920s – even in comparison to the relatively severe droughts of 2002-2005. This gives some indication of the possible range of natural variability which could exacerbate the further drying trend and suggests that the consequences were another drought of similar proportions to occur could be substantial, especially given the increased water demand of the present day.
Figure 7: Region 4: Annual rainfall from 1930 to date. Source: CSAG, 2007

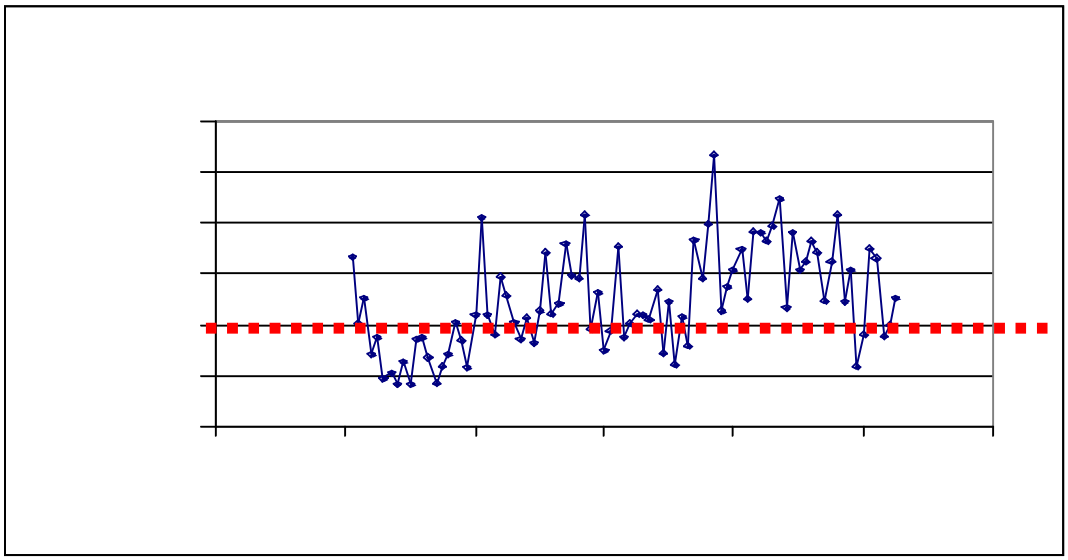
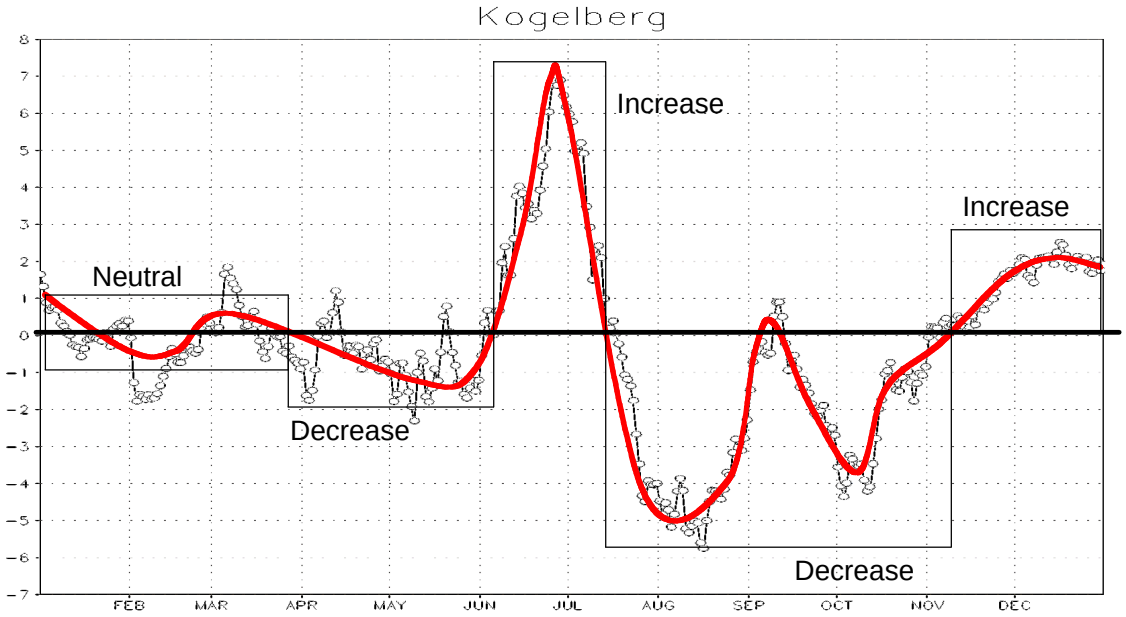


Figure 8 shows the sub-seasonal trends for one location (Kogelberg near Kleinmond). In this figure the trend for a moving 30-day window is calculated; thus each point on the graph is the trend over 50 years from 1950-1999 of the total rainfall of the 30 days centered on a day. The figure shows that in the core winter season there is a significant historical wetting trend, while the latter winter period shows notable drying. The net effect is to create a shorter winter rainfall season. Again, this potentially has consequences for activities that are dependent on the duration and timing of seasonal rains.

Figure 8: The sub-seasonal trends for precipitation for one location (Kogelberg). Source CSAG



Precipitation: Challenges to communities and livelihoods

Shortening shoulder seasons (autumn and spring) threaten the Western Cape's deciduous fruit export sector, which needs the cooling period in autumn to produce export-quality fruit.
The heightened drying factor adds to the creation of conditions suitable for veld fires in spring, summer and autumn (especially when coupled with increased wind velocity and higher temperatures – see below).
Veld fires threaten livelihoods, both directly (for example agriculture), and indirectly (for example tourism). When widespread, or when many veld fires occur simultaneously, they strain disaster management resources.

The Western Cape drought of the 1920s

Although droughts in themselves are not climate change, more frequent droughts may be part of a changing climate in a particular area. South Africa experiences periodic droughts. This includes several[14] devastating droughts including a sustained drought that started in 1919 and went on well into the 1920s in the Western Cape. The dry spell from July 1991 to June 1992 [with a mean rainfall of 15½ inches (390mm)] is reckoned as the fifth driest on record since 1920 (Vogel and Drummond, 1993). The other major post-war dry spells in order of severity were: 1925/26; 1923/24; 1932/33; 1921/22 and 1982/83. The most recent severe drought in the Western Cape was in 2003. A key question for the province now is whether it could sustain an extended drought of similar magnitude.

During the 1920s drought, farming was the staple and farmers had little option but to adapt, as policy makers and regulators were late in coming to their support. Large-scale failure of agriculture was one of the main features. Population levels were approximately one-third of current levels and infrastructure and services did not draw on water supply at current levels.

The direct losses of the 1919 drought (Union of South Africa 1924) alone were estimated by the Census Department at 16 million British pounds using pre-1914 prices,[15] or 308 billion rands[16] - about a third of

[14] Kanthack, F.E. (1930); SADC (1994); Vogel, C.H. and J. H. Drummond (1993)

[15] Lawrence H. Officer, "Five Ways to Compute the Relative Value of a UK Pound Amount, 1830 - 2005" MeasuringWorth.Com, 2006.

South Africa's GDP in 2005 prices. The Commission of Enquiry set up to investigate the issues associated with the periodic drought was also careful to point out that although the cost to sectors of the economy other than agriculture was not easily quantifiable, the drought indirectly *affected every profession, business and trade.*

Information in this case study was based on the following sources:

Union of South Africa (1922), *Interim Report of the Drought Investigation Commission*, Presented to both Houses of Parliament by Command of His Royal Highness the Governor-General, Cape Town: Cape Times Limited, Government Printers.
Union of South Africa (1924), *Drought Distress Relief Act, 1924*, Pretoria, the Union of South Africa.
Vogel, C.H. and J. H. Drummond (1993), "Dimensions of Drought: South African Case Studies. *GeoJournal*, Vol 30, No 1., pp 93-98.
SADC (1994), "Land use in tropical savannas", *South of the Environment in Southern Africa*, South African Development Commission, SADC.
Kanthack, F.E. (1930), "The Alleged Desiccation of South Africa", *Geographical Journal*, 76 (6): 516-521

Changes in temperature

Temperature has been steadily increasing globally. Although historical temperature data in the Western Cape is more sparse than the data for precipitation, the historical temperature records show a warming trend in nearly every location of the Western Cape, with greater increases further away from the coast. The projected changes mirror this factor. At this point, however, it is not possible to make accurate statements about particular localities. The suggestions are that the stronger trends may be associated with warmer minimum temperatures.

Summary – temperature

- Planning should be for a minimum of 1 °C warming by the late 2030s compared to the second half of the 20th century, and warmer minimum temperatures.
- The warming trend increases from the south-west to the north-east.
- Warming is most pronounced in the spring and summer months.

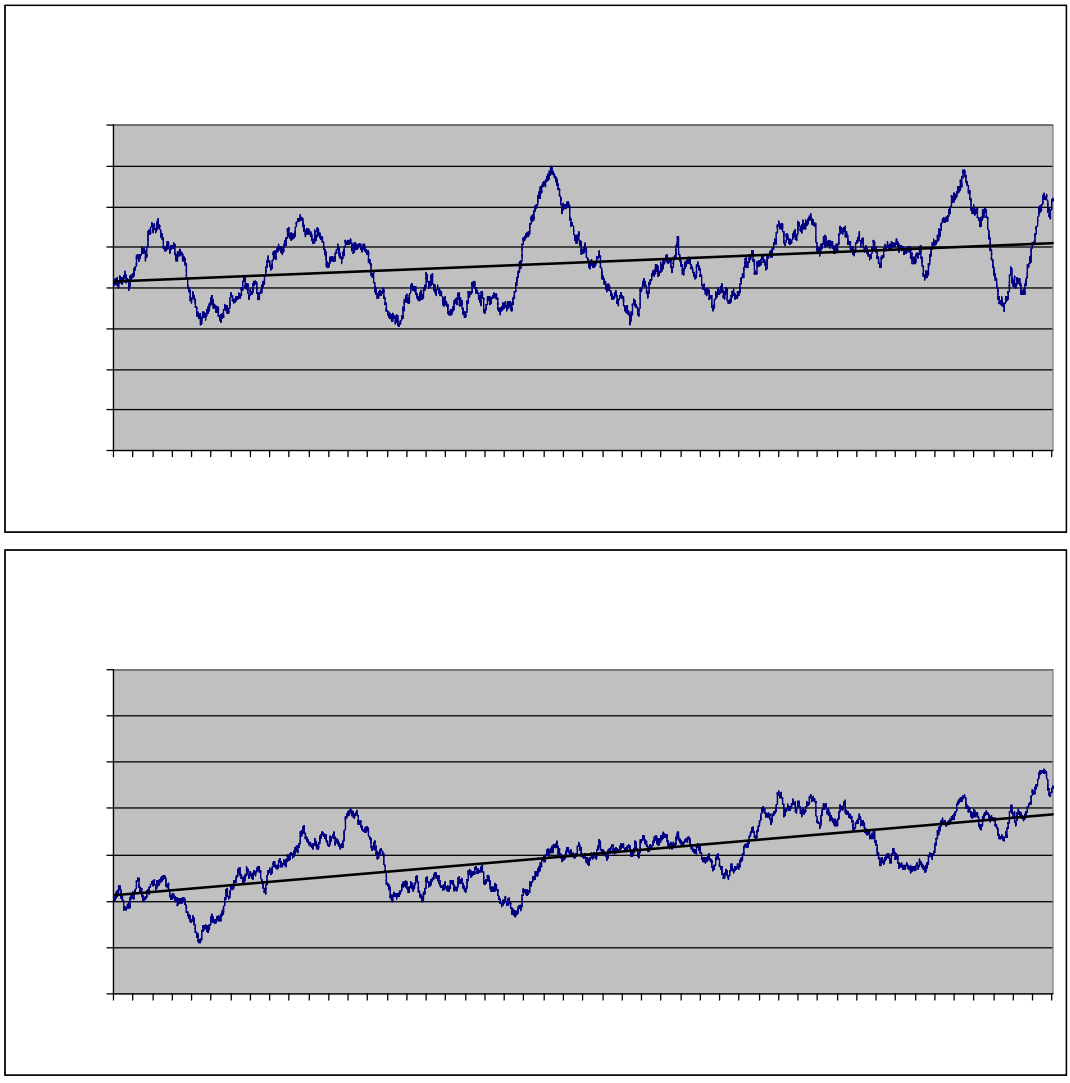
Threats to communities and livelihoods

An increase in minimum temperature increases crops' susceptibility to crop burning, as well as increasing the incidence of pests such as fruit fly.
Infrastructure shows sensitivities to increased temperatures, for example Telkom experienced infrastructure failure in the Clanwilliam area during the February 2007 heatwave.

Figure 9 shows the historical warming trend in daily maximum and minimum temperatures for a location in the Swartland.

[16] Using the GDP deflator approach and a subsequent conversion of UK Pound into Rand at ZAR14/Pound.

Figure 9: (a) Daily maximum temperatures and (b) daily minimum temperatures for the last 50 years, smoothed, with a 365 day moving average, for a location in the Swartland. The strongest warming trend is apparent in the minimum temperatures.



Source: CSAG, 2007

Changes in wind velocity

Average wind velocity is expected to increase in all seasons. This does not mean all days will be windier but that the prevailing wind will likely be stronger. This is associated with a stronger and more dominant south Atlantic high pressure system.

The increases are most notable in coastal regions. While seemingly modest, these are changes in the average, and reflect a significant change for coastal areas. Inter-annual and inter-decadal variability will continue.

Summary – wind velocity

- Mild to moderate increases in wind velocity in summer, autumn and spring.
- Moderate to strong increases in winter.
- Increased wind velocity when accompanied by corresponding drying will increase fire risk and evaporation potential.

Challenges to communities and livelihoods

Shack fires in densely-populated urban and peri-urban areas are exacerbated by strong winds. The resultant damage frequently leads to the displacement of entire communities.

The combined impact of stress factors

Apart from the changes in individual weather variables noted above (temperature, wind velocity, precipitation), there is a danger of stronger effects when two or more of the variables occur at the same time (for example both a strong wind and high temperatures). As an example, the western regions of the Western Cape will experience higher temperatures, longer dry spells, stronger winds and less rainfall. The combined effect of these weather conditions happening at the same time (as they frequently do in summer and autumn) will create much more dangerous conditions, such as the following:

- Conditions conducive to veld fires occur more frequently.
- Vulnerable communities are at higher risk, especially with regards to fire in the western parts of the Western Cape and floods in the southern Cape.
- Rising temperatures impact on crop activities, for example crop burn and higher incidence of pests such as fruit flies. Soil moisture levels are reduced (from an increase in temperature coupled with decrease in average precipitation).
- Increased stress on water supplies.

It is also important to note that inter-annual and inter-decadal variability will continue.

Some sectors of the Western Cape are already at the limit of their capacity. For example, some sectors within agriculture cannot cope with an increase in minimum temperature (i.e. if our hottest summer becomes the norm). Infrastructure has also demonstrated its threshold in some instances.

Table 3 summarises the climate impacts and related stress factors envisaged for the Western Cape.

Table 3: Climate Impacts for the Western Cape

Climate impacts for the Western Cape

Change to climate variable	**Examples of impacts**
Higher mean temperatures	• Increased evaporation and decreased water balance. • Increased severity of droughts (see below). • Increased incidence of pests such as fruit fly
Higher maximum temperatures, more hot days and more heat waves	• Increased incidence of death and serious illness, particularly in older age groups. • Increased heat stress in livestock and wildlife. • Increased risk of damage to some crops. • Increased susceptibility to crop burning. • Increased wild fire danger (frequency and intensity). • Increased threat to infrastructure such as Telkom. • Increased electric cooling demand and reduced energy supply reliability.
Higher minimum temperatures, fewer cold days and frost days	• Decreased risk of damage to some crops and increased risk to others. • Extended range and activity of some pest and disease vectors. • Reduced heating energy demand. • Increased risk to crops such as deciduous fruits that rely on cooling period in Autumn.
Decrease in precipitation	• Decreased average runoff, stream flow. • Decreased water quality. • Decreased water resources. • Decrease in shoulder seasons threatens the Western Cape fruit crops. • Increased fire danger (drying factor). • Impacts on rivers and wetland ecosystems.
Increased severity of drought	• Decreased crops yields and rangeland productivity. • Increased damage to foundations caused by ground shrinkage. • Increased fire danger. • Reduced economic activity including industry. • Decrease in positive investment environment in the Western Cape.
Decreased relative humidity	• Increased wildfire danger. • Increased comfort of living conditions at high temperatures.
Increased intensity of extreme events	• Increased risk to human lives and health. • Increased storm surge leading to coastal flooding, coastal erosion and damage to coastal infrastructure. • Increased damage to coastal ecosystems. • Increased soil erosion. • Increased pressure on disaster relief systems.
Increased mean sea level	• Salt water intrusion into ground water and coastal wetlands. • Increased coastal flooding (particularly when combined with storm surges).

Source: OneWorld Sustainable Investments

The Western Cape's greenhouse gas emissions (GHGs)

The Western Cape is a relatively low emitter compared to other parts of the country. Most of the electricity produced in South Africa comes from coal-fired stations in Mpumalanga and this sector contributes significantly to South Africa being the 19th largest global emitter of greenhouse gases**.** Transport contributes about 11% of the country's emissions.

The province produces 30,527 thousand tons of carbon dioxide (CO_2) per year, with industry accounting for almost half of this amount (48%). The transport sector is the next most important source of CO_2 emissions (22%). Residential facilities produce 15% of the total emissions from the province, whilst commerce and public services are responsible for 7%, agriculture for 6%, and mining and quarrying for 2%.

When the emissions are considered in terms of fuel type, electricity is responsible for half of the emissions; coal (at source) has a share of 15% while petrol is responsible for 14%. Diesel produces 10.7% of emissions, fuel oil 5%; paraffin and jet fuel <1%; LPG < 1%, and all other sources 2%.

There is sufficient evidence that reliance on fossil fuel-based energy sources is no longer a solution to the Western Cape's energy security issues, nor to local air quality problems.

Why we must reduce our carbon emissions

Box 2 makes the argument for the Western Cape taking a mitigation response as part of its climate change response strategy and action plan.

Box 2: Why do we need a mitigation response?

Anthropogenic greenhouse gas (GHG) emissions are loading the atmosphere with ~8.8 GtC (Gigatonnes of carbon) which equates to 32.3 $GtCO_2$ annually at present. The oceans and vegetation are absorbing about half of that. Carbon dioxide equivalent concentrations in the atmosphere have risen from 280 ppm before the industrial revolution to ~430 ppm now (these values include methane – CH_4 and nitrous oxide – NO_2). This increase has created a global average radiative forcing of about 2.3 $W.m^{-2}$, which has pushed up global temperatures. Observed effects of this are contracting polar ice sheets, glacial retreat everywhere, a sea level rise of about 1.5 mm/a, earlier spring in the northern hemisphere and observed rainfall changes in many locations around the world, amongst numerous other effects.

Because carbon dioxide has a long life in the atmosphere (~50 years on average), and there are insurmountable technological and financial barriers to switching immediately from fossil fuel dependence to alternative energy sources with lower GHG emission rates, atmospheric concentrations of CO_2 will continue rising for the foreseeable future. The world is committed to at least a doubling of CO_2 equivalent concentrations to 550 ppm or more by 2100, but possibly trebling under Business as Usual (BAU) emissions scenarios, in which dependence on carbon-based fossil fuels for transport and energy generation continues and grows.

Global average atmospheric temperatures will rise about 2-5 °C over the next 100 years, with a 50% chance of average temperatures exceeding 5 °C if the GHG concentration trebles. These projected temperature increases are unprecedented: the world has no experience of what this could do to global climate and all related human and ecosystem dependencies, or how to cope

with such changes. At the upper end of projected temperature rises, the global climate impacts could be substantial or even disastrous.

South Africa is a signatory of the United Nations Framework Convention on Climate Change. Under the Kyoto Protocol, South Africa, as a developing nation, does not have to take active steps to mitigate this country's carbon emissions. While mitigation efforts are not going to be effective in the short term (10 - 30 years), we must make progress in developing technologies and approaches to reducing carbon emissions. International concern is already leading valuable markets in the European Union to impose carbon emission reduction targets on their suppliers. The Western Cape stands to lose market share on agricultural goods, for example, if no attempt is to be made to achieve at least carbon neutrality (no net emission of carbon for a produced good).

[Source A. Chapman, 2007**]**

The Western Cape Government's response to Climate Change

The Western Cape Government considers climate change a significant issue and has already taken steps toward addressing the problem. The Premier of the Western Cape, in his State of the Province Speech in February 2007, identified Climate Change as one of the strategic priorities to be addressed. Examples of actions taken by provincial government and industry in responding to climate change include the following:

- In 2005, the Department of Environmental Affairs and Development Planning (DEA&DP) commissioned the "Status Quo, Vulnerability and Adaptation Assessment of the Physical and Socio-economic Effects of Climate Change in the Western Cape" (Status Quo Review) which resulted in:
    - The commissioning in 2006 of the Climate Change Response Strategy and Action Plan. This will be launched at the Climate Change Conference being planned for early June 2007.
    - The Western Cape is represented on the National Climate Change Committee and is in the process of constituting the Provincial Climate Change Committee (PCCC) which will monitor and coordinate provincial climate change activities and ensure ongoing representation at a national level.
    - The Western Cape Government signed the Montreal Accord in November 2005.
    - Various provincial departments, such as Agriculture and the Provincial Disaster Management Unit, have identified climate change as one of their strategic imperatives and there is a growing groundswell of attention to the call to respond to our changing climate.
    - The Western Cape Government is in the process of finalising the Integrated Energy Strategy which takes cognisance of energy development in relation to climate change – in particular to reducing greenhouse gas emissions.

There is a significant *core of research institutional capacity* in the province and the Western Cape is home to renowned climatologists and scientists that have international recognition and some of whom sit on the Inter-governmental Panel on Climate Change (IPCC).

The province is also home to an *active and interested community* that demonstrates its commitment to environmental issues and to strengthening the adaptive capacity of vulnerable

communities – for example the Khayelitsha Development Forum which wants to see climate change being integrated into its development planning processes.

Goals, objectives and guiding principles of the Response Strategy

Goals and objectives
The government of the Western Cape aims to ***strengthen the province's resilience to climate change and its adaptive capacity*** in terms of the provincial economy and in vulnerable communities. It further aims ***to maintain the Western Cape's status as a low greenhouse gas emitter*** by reducing the province's carbon footprint.

As such, the *goals and envisaged outcomes* of the Response Strategy and Action Plan are:

- **Maximised and strengthened provincial resources –** ***For example, establish a cohesive water supply and infrastructure management programme that integrates climate impacts and risks.***

- **Improved knowledge and monitored progress –** ***Establish a focused climate change and weather information programme.***

- **Developed and managed resources for a vibrant economy: Establish clear linkages between stewardship, livelihoods and the economy –** ***Land care and resource conservation; Development Planning and Livelihoods – strengthening social systems and increasing the capacity to cope and shorter term gradual adaptation with space for dealing with higher probability extreme events and disasters.***

- **Reduced carbon footprint –** ***Air quality management; household fuel replacement; cleaner fuels for transport; energy efficiency and renewable energy – maximizing benefits through stimulating and subsidizing innovation in clean and renewable technologies.***

These will be achieved through:

- ❑ Providing a co-ordinated, consistent, timely and effective response to the complex issue of climate change and its impacts.
- ❑ Acting now and into the future through planning, adaptation and mitigation to respond to our changing climate.
- ❑ Identifying and taking advantage of opportunities that may emerge from our changing climatic conditions.
- ❑ Building community awareness and understanding of climate change issues and the likely consequences for the province and actively involving the community in that response – thus driving behavioural change.

The *objectives* in developing the Response Strategy and Action Plan for the Western Cape are the following:

- ❑ To identify the likely changes in climate in the Western Cape at least for the period 2030-2045.
- ❑ To assess the current situation of various vulnerable sectors in the Western Cape (livelihoods, communities, sectors).

- To identify the risks and vulnerabilities of these sectors and communities to the identified climate change effects.
- To identify, evaluate, cost and prioritise specific achievable adaptation and mitigation responses to the effects of climate change in the Western Cape.

Guiding Principles underpinning the Response Strategy

- ***Government leads by example*** **but shares the responsibility by building on cooperative partnerships across all levels of government, industry and the community.**

- ***An integrated, consistent long-term approach*** **and framework underpinned by the sustainable development goals of the province.**

- ***Assistance to the province's community and industry*** **through facilitating the provision of information, policy guidance and incentives where applicable, and regulation where necessary.**

Action areas and key initiatives

Action areas

The following aspects have been identified as forming the basis of the programmes that constitute the action plan:

Adaptation, Land stewardship, Land use planning and Strategic Planning

- Implementation Programmes.
- Integrating Climate Change into development planning.

Mitigation, Land use management and Strategic Planning

Maintaining the Western Cape's relatively low base of greenhouse gas emissions through:

- Implementation Programmes (energy; air quality and waste).
- Demand-side Management and pricing strategies.

These actions are supported by the following activities and inputs:

Improving our knowledge - Research component

These programmes incorporate and are supported by targeted research programmes that are essential in order to continue to improve our knowledge of climate change impacts in the province and ways to address them. Targeted research will in turn support implementable programmes.

Monitoring our progress

The rate of climate change as well as our progress in responding to the impacts of climate change will be monitored, and the information used to inform future actions, the Western Cape Community and early warning systems.

Educating, Informing and Involving (Communications strategy, a supplementary report to this response strategy and action plan) - Government tiers, the private sector and Western Cape communities (particularly vulnerable communities) will be informed and actively involved in the Strategy to ensure they are empowered to respond to the challenges posed by our changing climate.

This structure is illustrated in Figure 10.

Key initiatives

The following key action items have been identified and are developed into programmes in the action plan. The action plan facilitates the implementation of the Strategy.

The Western Cape Government (in partnership with key stakeholders, including research institutions, industry organisations and community groups) will provide leadership in coordinating climate change activities in the Western Cape and will:

1. Implement, monitor and report on key programmes identified to strengthen the province's adaptive capacity in the different prioritised natural and productive resource areas.
2. Incorporate climate change issues (to include coastal vulnerability, the impacts of sea level rise and storm surge risk) into development planning and approval processes and develop practical planning tools to assist local government in taking predicted climate change impacts into consideration.
3. Develop and implement demand-side management programmes and associated pricing strategies through integrating resource scarcity and risk factors into tariff structures and incentivising efficiencies and behaviour change.
4. Conduct new research projects in conjunction with the appropriate research institutions and universities to better inform programme implementation such as Integrated Pest Management where research is required to identify the pests most responsive to climate change impacts such as temperature increase.
5. Strengthen the adaptive capacity of systems and resources (especially water) that are most threatened by the impacts of climate change, and without which livelihoods and economic productivity are threatened.
6. Ensure that emergency management strategies incorporate climate change risks and impacts, particularly with reference to the likely increase in the occurrence of extreme events. Ensure communities are involved in these strategies and empowered to benefit from them.
7. Support efforts to improve and extend renewable energy technologies and, if need be, to regulate accordingly.
8. In partnership with research institutions and other departments, conduct research into the climate change impacts on tourism, fisheries and other identified industry sectors, and the potential opportunities created by climate change in these sectors.
9. Implement monitoring programmes and ensure our progress in responding to climate change is known, reported and can inform future strategies and actions.
10. Implement a communications strategy that drives behaviour change, supports the actions outlined in the Plan and informs and educates the Western Cape community of climate change impacts and progress.

The Action Plan

Introduction

The Western Cape's Climate Change Action Plan is based on a set of integrated cross-sectoral planning and implementation programmes. These programmes include both mitigation and adaptation responses:

1 Adaptation response strategy and programmes

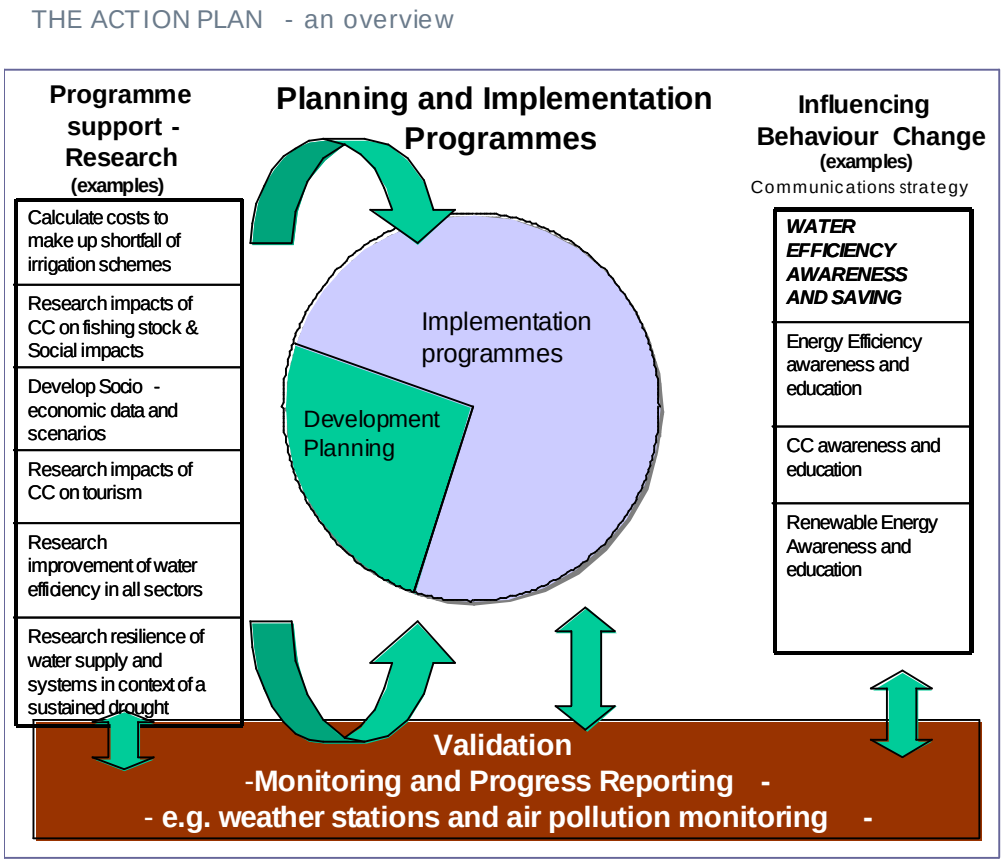
1 Integrated Water Management Programme
2 Climate change, weather research and information programme
3 Land stewardship and Livelihoods Programme

2 Mitigation response strategy and programmes

1 Energy, transport and air quality management programme
2 Waste management programme.

The action plan overview is illustrated in Figure 10.

Figure 10: The Western Cape Climate Action Plan - An Overview



Source: OneWorld Sustainable Investments

Action Plan parameters and overview

The Response Strategy and Action Plan has been developed through partnerships with key provincial stakeholders and through a process of ongoing consultation. It has been informed by the Status Quo Review conducted in 2005[17]. The Action Plan contains high level cost estimates and identifies action custodians and key role-players for each programme or project. The spatial parameters are outlined in the relevant section below.

Guiding principles

The Western Cape government will take the main leadership role in the coordination of local adaptation and mitigation strategies, and will participate in national policy development and programmes.

Uncertainty about the nature and magnitude of the impacts of climate change underlies the need for ongoing targeted research that will remain an underpinning component of action with respect to climate change impacts and adaptation and mitigation responses. However, deferring action until all questions are answered is not responsible and a range of actions can be put in progress now, averting serious future damage and/or preventing the need for more costly remedial action in the future.

Planning for climate impacts risks is a central theme to adaptation and the Western Cape government intends to take a proactive approach with a focus on risk minimisation while offering protection to the province's most vulnerable communities, maintaining livelihoods and ensuring general population health and safety through planned responsive action.

The Strategy and Action Plan requires a range of actions (inputs, activities and outputs) that are designed to achieve the stated outcomes. Each action is recommended after consideration of the following aspects:

- the problem
- the solution
- the mitigating impacts (economic, social, environmental and livelihood) of taking the action.

In the Climate Change Response Strategy and Action Plan, less than 15% of the total budget for the Western Cape government is allocated to mitigation. The majority of the budget – the remaining 85% – goes towards increasing adaptive capacity, strengthening resilience, and minimising risk. Three of the four outcomes of the strategy address adaptation responses.

Government leadership

[17] Midgley, *et al*. 2005 *A Status Quo, Vulnerability and Adaptation Assessment of the Physical and Socio-economic Effects of Climate Change in the Western Cape.*

The Strategy and Action Plan is extensive, cross-cutting and entails a large number of government institutions, private enterprise sectors, research institutions and all communities – including the most vulnerable. The challenges involved in achieving the success of this response to climate change are not inconsiderable and in many respects the Western Cape is taking a lead in that it is the first region in South Africa and indeed on the African continent that is developing a robust and detailed response (with defined strategic parameters) to climate change. The National Climate Change Strategy serves more as a discussion document and does not as yet provide clear strategic principles in response to climate change that a province such as the Western Cape could use as a point of departure and as a clear guideline. This is despite the fact that South Africa is a signatory to international agreements.

Through this Strategy and Action Plan the government of the Western Cape, with its various departments and local authorities, will take the lead in coordinating the Western Cape Province's response to the complex issues of climate change. This will be through cooperation with research institutions and private enterprise as well as government agencies. *However, the onus is on government to initiate, manage, oversee, support and monitor all aspects of the Strategy and Action Plan.* It is envisaged that to implement the Strategy and Action Plan successfully, innovative institutional structures and arrangements will be required.

Cross-sectoral institutional arrangements

Since climate change affects all sectors, the nature of the Western Cape's response thereto (and therefore the Strategy and Action Plan) are by definition also cross-cutting. The effective facilitation of the Strategy and Action Plan is dependent on appropriate institutional arrangements that allow implementation across different sectors. In some cases it seems likely that current institutional arrangements (i.e. provincial/municipal) will not be suitable since there is frequently no consistency of accountability. In other words, institutional arrangements do not currently facilitate the cross-cutting nature of an integrated response to climate change. For example, some of the responses and actions suggested in the Strategy and Action Plan require cooperation across municipalities such as water where it is suggested that water efficiency measures be effected throughout the province. The coordination of a provincial plan for water therefore requires the buy-in of 30 individual municipalities. In such cases it may be necessary first to establish the authority (or action custodian) that will be responsible for the oversight of these actions across the province. Furthermore, the budgetary requirements for implementation of the strategy may also require a provincial authority or authorities.

A climate change response with communities as key stakeholders

The objectives of the Strategy and Action Plan have been developed with consideration to the Provincial Growth and Development Strategy, the Sustainable Development Implementation Plan, the Spatial Development Framework and the Integrated Energy Strategy; all against the backdrop of the researched and projected impacts of climate change and the identified risks and vulnerability in the Western Cape.

It is particularly important to increase community awareness and understanding of potential climate change impacts and to take a lead in informing the community about these impacts as well as possible adaptation and mitigation strategies based on risk management principles. Actions identified will take place across the broad areas of:

- Adaptation
- Land use / land stewardship and Infrastructure Planning
- Population and Community Health and Safety
- Livelihoods

- Mitigation.

A comprehensive, integrated **Communications Strategy** has been developed to support and communicate various aspects of the Strategy and Action Plan to all stakeholders.

Communications strategy

In 2005 the Western Cape Provincial Department of Environmental Affairs and Development Planning (DEA&DP) commissioned a *Status Quo Report* assessing the Western Cape's vulnerability and adaptation potential to the physical and socio-economic effects of climate change. The report was presented to the public in an open stakeholder meeting in early 2006, out of which emerged the drafting of a Terms of Reference for a Western Cape Climate Change Response Strategy and Action Plan. Included in the Terms of Reference was a call to design and develop a **communications and awareness strategy** with the principle aim to "investigate and advise on:

- Climate change awareness and appropriate personal behaviour changes in the general (Western Cape) population.
- Appropriate set of communication devices/resources about climate change to be used in communicating the Climate Change Response Strategy and Action Plan to stakeholders on different levels.

Objectives of the Western Cape Climate Communications, Education and Public Awareness Strategy

The communications, education and public awareness strategy has the following major focus:

- The dissemination of general climate change information and education about specific mitigation and adaptation responses to the general public, the media, laypeople and schools.
- Focused communications, education and training relating to climate change, climate change response, the Western Cape Climate Change Strategy and Action Plan, and policy development to government departments and officials.
- Focused communications, training and information about climate change, impacts, and relevant adaptation and mitigation responses relating to **individual sectors (including vulnerable sectors) - industry, agriculture, vulnerable communities.**

Recommendation: *Resilience of communities, countries and enterprises to the impacts of climate change can be increased by raised awareness. Timeous information allows various sectors to plan for adapt and make appropriate changes. Therefore a robust information and communication system is essential to prepare all sectors of the community for expected climate change impacts.*

'Providing information and explanations is … vital for generating public and stakeholder support for government policies and regulations. Public outreach can encourage voluntary changes in habits, address the arguments of those who oppose specific actions and help to prepare the younger generation for living in the climate-change world that they will soon inherit.' *(UNEP, Raising awareness of climate change, 2006)*

The objectives of the Climate Change Communications, Education and Public Awareness (CEPA) Strategy and Action Plan are the following:

1. To invite and engage stakeholders from all sectors and communities to join the Western Cape government in adapting and mitigating against climate change. **The platform for this engagement already exists (see Stakeholder Report of main Strategy and Action Plan), and the momentum must be sustained.**
2. To raise awareness and educate about climate change and its impacts amongst the following audiences:
    - within government departments and individual sectors
    - all sectors of the general population
    - business, industry and labour.
3. To communicate and raise awareness about how we can **adapt to this new situation, and to encourage adaptive behaviour**
4. To raise public awareness of the four focal points of the Western Cape Climate Change Response Strategy and Action Plan, and what government is doing to implement these:
    - Integrated water management
    - Land stewardship and livelihoods
    - Climate change and weather information
    - Energy efficiency and reducing our carbon footprint.
5. To raise awareness and inform about how government is supporting adaptation and mitigation responses while working towards achievement of sustainable development goals, for example:
    - by working to make cheap public transport available;
    - by implementing a Solar Water Heating programme in new housing;
    - by building houses that are energy-efficient;
    - by mapping the 1:100 year flood plan to help pre-empt disasters.

These objectives will be achieved through an integrated climate communications, education and public awareness (CCEPA) strategy through various initiatives:

- **Educating and training government departments and officials** on climate change and on the Western Cape Climate Change Strategy and Action Plan and related policy development challenges.
- **Using existing climate change stakeholder engagement platform/s (e.g. ward level engagements) to continue the discourse, communication and awareness raising around climate change that was begun during the development of the Western Cape Climate Change Strategy and Action Plan. (See the Stakeholder Supplementary report.)**
- Communicating climate change and its impacts to the public through various media and tools (including training for journalists and other media professionals).
- Communicating and raising awareness of the four key outcomes of the **Western Cape Climate Change Strategy and Action Plan** and government's response to climate change (i.e. water resource management; land and livelihoods; climate change and weather research; reducing our carbon footprint).

Stakeholders in a Western Cape Climate Communications, Education and Public Awareness Strategy

The stakeholder engagement process contributed central input to the development of the Western Cape Climate Strategy and Action Plan. Experience gained during this process has informed the development of the Communications, Education and Public Awareness Strategy. Government, labour, business and civil society were targeted. The following excerpt is taken from the Stakeholder Supplementary Report of the Western Cape Climate Change Strategy and Action Plan, and explains the approach used.

***Recommendation**: A series of workshops / stakeholder engagements have already been planned. These should be used to continue the climate change communications process already begun.*

Stakeholder approach

The Department of Environmental Affairs and Tourism defines stakeholder engagement as a spectrum of increasing levels of engagement between stakeholders in the decision making process. These levels of engagement are depitcted below, with related objectives (DEAT 2002, IEMI Series 3).

Level of engagement	**Objective**
Inform	Provide balanced and objective information to improve understanding of issues
Consult	Obtain feedback from stakeholders on analysis or decisions
Involve	Work directly with stakeholders to ensure issues and concerns are understood
Collaborate	To partner with stakeholders on all aspects of the decision making process
Empower	Placing the decision making powers in the hands of stakeholders

Source: DEAT, 2002

These terms of reference effectively translate into employing the top four levels of stakeholder engagement with objectives as defined in the table above.

Conclusions and recommendations of the stakeholder engagement process above are as follows:

Conclusions and recommendations

Stakeholder platforms

It is suggested that further efforts are employed to engage the youth and women structures on the potential impacts of climate change and the region's responses thereto. A byproduct of such

effort is the envisaged positive changes in behavior subsequent to raising awareness levels via the engagement process.

It is also recommended that further effort be employed to engage Cosatu, in spite of their lack of commitment to this process to date. It is significant that they represent an important number of the very people whose behavior changes are the subject of this work.

The experiences emanating from the stakeholder engagement process in this work suggest a need to review the relationships around the PDC social partnership mechanism:

- The PDC social partnership mechanism seems to have capacity challenges that limit its ability to assist the stakeholder engagement processes within the social partnership mechanism, probably due to its design.

- In strengthening the PDC mechanism, it would help if capacity is also added to facilitate **ward level engagements** as an area of special focus. The Constitution of our land was written at this level, and it is only fitting that high impact challenges like climate change receive input and impact on awareness and education at this level.

Ward level engagements

There is a layer of civil society that can and should be accessed in all major impact works – via the ward councilors. This point is particularly relevant as it talks directly to the desire to positively change the behavior of all the people in the Western Cape region. This report is submitted before the test stakeholder engagement pilot at ward level takes place with a councilor in Mitchell's Plain. The commitment publicly declared in the meeting of 28 February by the councilor in question and related dialogue thereafter forms a sufficient basis for optimism that this platform can enhance social dialogue.

Awareness and education

Marginalised communities need extensive awareness campaigns around climate change if the desired changes in behavior are to materialize.

- Some awareness campaigns can translate into economic activity for these communities, e.g. training around fire prevention challenges should be a deliberately localized activity. Capacity can and should be built within these communities to generate the centre around which behavior changes are sustained. It is an anomaly that buildings in central Cape Town have fire drills by law, whereas fire prone communities depend on external inputs for their responses to such fires!
- It is significant that government, business and labour be sensitized to their responsibilities in ensuring the effectiveness of the integration of effort around climate change. The lack of urgency in some of the sectors can be attributed to lack of awareness/education on the subject matter. This might also include the inability to contextualise various sector contributions or impacts in the PDC social partnership mechanism.

Recommendation: *It is strongly recommended that the lessons learnt from the stakeholder engagement process be used in furthering the Climate Communications, Education and Public Awareness Strategy for the Western Cape. – John Notoane, lead designer and facilitator of the Stakeholder Engagement Process of the Western Cape Climate Change Strategy and Action Plan, 2007.*

Stakeholder engagement and consultation

Stakeholder consultation has been conducted through different platforms***. Focus group sessions*** were held in the prioritised sectors and segments (prioritised for their risk and

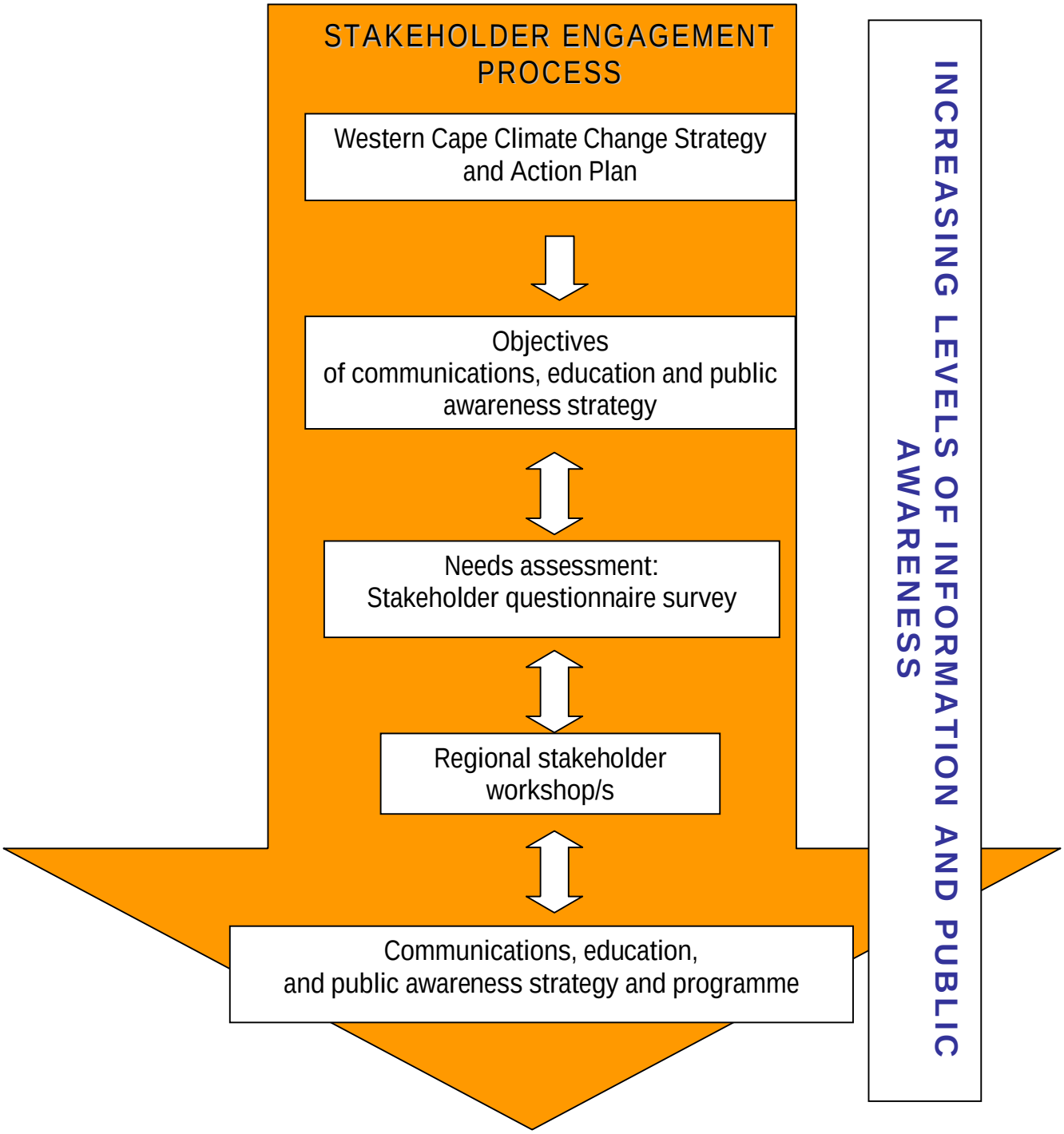
vulnerability). Four ***general stakeholder workshops*** have been held at different stages of the strategy development. Two were held in Cape Town (at Kirstenbosch), one in George and one in Oudtshoorn. A further two workshops are being scheduled to present the final strategy to stakeholders that have contributed to the process. Government department sessions with Heads of Department, Chief Directors and Directors have been conducted to discuss the Strategy and to obtain key inputs. A number of presentations have been made to community-based stakeholders such as the Development Agencies. Numerous interviews have also been held. Table 1.4 shows an example of a stakeholder summary for a local government authority.

Table 1.4: Example – a stakeholder summary for a local government authority

Stakeholder	***Summary of objectives and concerns***
Residents within the local authority's jurisdiction	Maintenance of employment opportunities, job creation, water availability and maintenance of quality, environmental degradation concerns, local authorities' service levels and capacity
Businesses operating in the area	Quality of infrastructure, availability of water and energy (uninterrupted supply), water allocation and competitiveness of the resource, retention of staff and customers, retention of market (particular concerns as to the export market), local authority service levels, response required to market demands based in global warming – for example Marks & Spencer have announced their objective to be carbon neutral by 2012. They are passing the pressure onto their suppliers
Visitors to the region	Availability of services and resources, quality of infrastructure, accessibility, environmental protection
Local authority workforce	Maintenance of employment, capacity, ability to deliver on service level agreements, ability to make informed development planning decisions
Government agencies	Compliance with legislation and policies that overlap jurisdictions, capacity and knowledge, ability to influence, ability to make informed development planning decisions, lack of data

The insights and information gained regarding the stakeholder process and input to the Western Cape Climate Change Strategy and Action Plan can be found in the Stakeholder Supplementary Report to the main report (DEA&DP, 2007).

Figure 11 shows the stakeholder engagement process involved in developing a Climate Communications, Education and Public Awareness Strategy for the Western Cape.
Figure 11: Developing a communications, education and public awareness strategy and programme in a stakeholder engagement process



Target audiences and key messages of the Communications, Education and Public Awareness Strategy and Action Plan

The target audiences of the Western Cape Climate Communications, Education and Public Awareness Strategy and Action Plan are all stakeholders. The Western Cape Climate Change Strategy and Action Plan was developed through a process of stakeholder engagement with experts, communities, industry, agriculture and representatives of government in various capacities. Through this process a strong platform was established and a discourse opened around climate change and the way forward in addressing the challenges.

Recommendation: *The* ***existing climate change stakeholder platform*** *should serve as the primary tool for communication, education and public awareness of the Western Cape Climate Change Strategy and Action Plan. The participants in these forums are well-equipped to feed into and act as a sounding-board for the ongoing development of* ***communicating, educating and raising public awareness of climate change.***

Types of messages and information

The Western Cape Climate Communications, Education and Public Awareness Strategy and Action Plan includes the following aspects:

- Communications and public awareness raising about climate change
- Communications about the Western Cape government's Climate Change Strategy and Action Plan
- Targeted information for particular communities (e.g. information about climate changes relating to agriculture)
- Education and training for government departments and officials who will implement the Western Cape Climate Change Strategy and Action Plan.

Targeted messages for different audiences

In order for a climate change response strategy to be effective, messages need to be packaged appropriately for different audiences. Given that the overall objectives of a climate strategy and action plan are to facilitate adaptation and mitigation responses, different sectors of the Western Cape have different needs in terms of information. Householders need to know that climate change makes scarce resources (such as water) more scarce, and therefore more expensive. Climate change will affect our choices of energy use, and the cost of energy. A fisherman on the West Coast may need to become aware of the fact that climate change is likely to affect catch rates, the availability of some fish, and fishing Operational Management Procedures. Farmers need specific information about climate change and long-term weather in order to choose appropriate crops or adjust planting times. Government officials, who are at the forefront of the implementation of the Climate Change Strategy and Action Plan need detailed information and understanding of climate change impacts, and responses/actions in the Action Plan, both for implementation of the strategy and for ongoing development of appropriate policies. Government departments and officials and other individuals and sectors - require education and training in climate change and adaptation and mitigation responses.

- In general, messages about climate change and adaptation/mitigation responses are more general and broader when targeting the general population (national or regional), households, schools and laypeople (i.e. general climate change information; mitigation and adaptation responses).
- At the next level – a provincial level – the message becomes more detailed and more focussed – for example politicians and businesspeople need to know generally that climate change has enormous costs if not addressed, but that addressing it can have benefits for the business.
- At the local level, the message needs to be targeted, focussed and detailed. Specific information for particular sectors needs to be supplied (as well as climate change

information for particular geographic regions when this becomes available[18]). Other sources of information / data banks (for example regarding weather and climate change for farmers) need to be supplied.

During the Western Cape's Renewable Energy and Climate Change Summit in June 2007, Premier Ebrahim Rasool spoke of the need to develop a discourse around climate change and our response to it – a discourse between the public (and the media), industry, business and science.

Table 4 shows different types and levels of information and messaging suitable for different audiences.[19]

[18] Currently, climate science does not allow fine resolution spatial projections for climate change in the Western Cape. These research requirements appear in one of the four main outcomes in the Western Cape Draft Climate Change Strategy and Action Plan.
[19] As suggested by Dr Guy Midgley, personal comm., 2007, adapted.

Table 4: Different levels of information and messaging for different audiences

Audience		Type of information	Sample message/s	Level of detail
National level	General audiences: ▪ media ▪ schools ▪ laypeople ▪ households ▪ communities	General information about the broad context of climate change: ▪ the 'big picture' of climate change ▪ national threats of climate change **Specific messages about mitigation and adaptation responses – 'This is what you can do.'**	Climate change will affect the Western Cape: - Let's save water. Let's switch off the lights. Let's use public transport. Let's demand public transport! Let's support our farmers in bad years, Let's keep fires under control, Let's fight invasive alien species.	**General messages about climate change** **+** **Specific messages about mitigation / adaptation measures** **MORE SPECIFIC MESSAGES ABOUT CLIMATE CHANGE AND IMPACTS** **+** **SPECIFIC MESSAGES ABOUT ADAPTATION / MITIGATION MEASURES**
Provincial level	Politicians	**General information about climate change:** ▪ Costs of climate change - not doing anything (business as usual) versus costs of adapting and / or mitigating ▪ Potential risks and damages **Specific messages about mitigation and adaptation responses – 'This is how you can benefit.'** ▪ Potential to benefit	We can't afford to take the risk of not acting now. / It is cheaper to act now than pay for the damages of climate change later. We can do things that make good sense even without climate change	
	Business and industry Labour as an institution	**General information about costs of climate change:** ▪ Costs of climate change - not doing anything (business as usual) versus costs of adapting and / or mitigating ▪ Potential risks and damages **Specific messages about mitigation and adaptation responses – 'This is how you can benefit.'** ▪ Potential to benefit (e.g. CDM; energy-efficiency) ▪ Industry-specific information about savings and investments	Saving energy will save your organisation money, and will make you more competitive on international markets, especially if a 'zero carbon footprint responsibility' becomes a selling point. Labour: Increase capacity for job retention in the face of climate change pressures. Investigate investment potential for labour in the CDM (empowerment); -- with emphasis on CDM projects that yield job creation and capacity building opportunities.	

Audience	Type of information	Sample message/s	Level of detail

Audience		Type of information	Sample message/s	Level of detail
Local level (Government: economic resources, infrastructure, built environment, livelihoods, disasters)	Individual sectors: 1. Western Cape government officials and departments ▪ water authorities ▪ marine and coastal management ▪ transport authorities ▪ air quality authorities ▪ health authorities ▪ disaster response planning and management ▪ local authorities ▪ development planning ▪ energy ▪ social systems / vulnerable livelihoods and communities	**Specific detailed and targeted information about climate change and its impacts relevant to each sector:** ▪ Climate change and climate change impacts ▪ Sources of relevant information (e.g. websites; brochures etc.) **Specific detailed and targeted information about adaptation and mitigation responses relevant to each sector:** ▪ The Western Cape Climate Change Strategy and Action Plan – relevant details and implementation	Detailed targeted information: Example (water): Water resources are vulnerable/fragile. Solutions: fixing leaks, etc. Example (energy): Solar Water Heaters are cost-effective, create jobs and save energy.	**SPECIFIC DETAILED TARGETED INFORMATION RELEVANT TO EACH SECTOR/ RESOURCE/ DEPARTMENT/ COMMUNITY:** **EDUCATION AND TRAINING**
Local level (vulnerable economic sectors)	Agriculture Fisheries Tourism	**Specific detailed and targeted information about climate change and its impacts relevant to each sector:** ▪ Climate change impacts (detailed) **Specific detailed and targeted information about adaptation/ mitigation responses relevant to sector:** ▪ The Western Cape Climate Change Strategy and Action Plan – relevant details and implementation ▪ Sources of relevant information (e.g. websites; brochures etc.)	It makes sense to plan medium term, and quantify the risk of crop failure. It makes sense to invest in research on alternative crops/ strategies. It makes sense to minimize your carbon footprint. It makes sense to consider alternative industries / parallel economies. Climate change reduces already dwindling fishing stocks further – fish sensibly.	

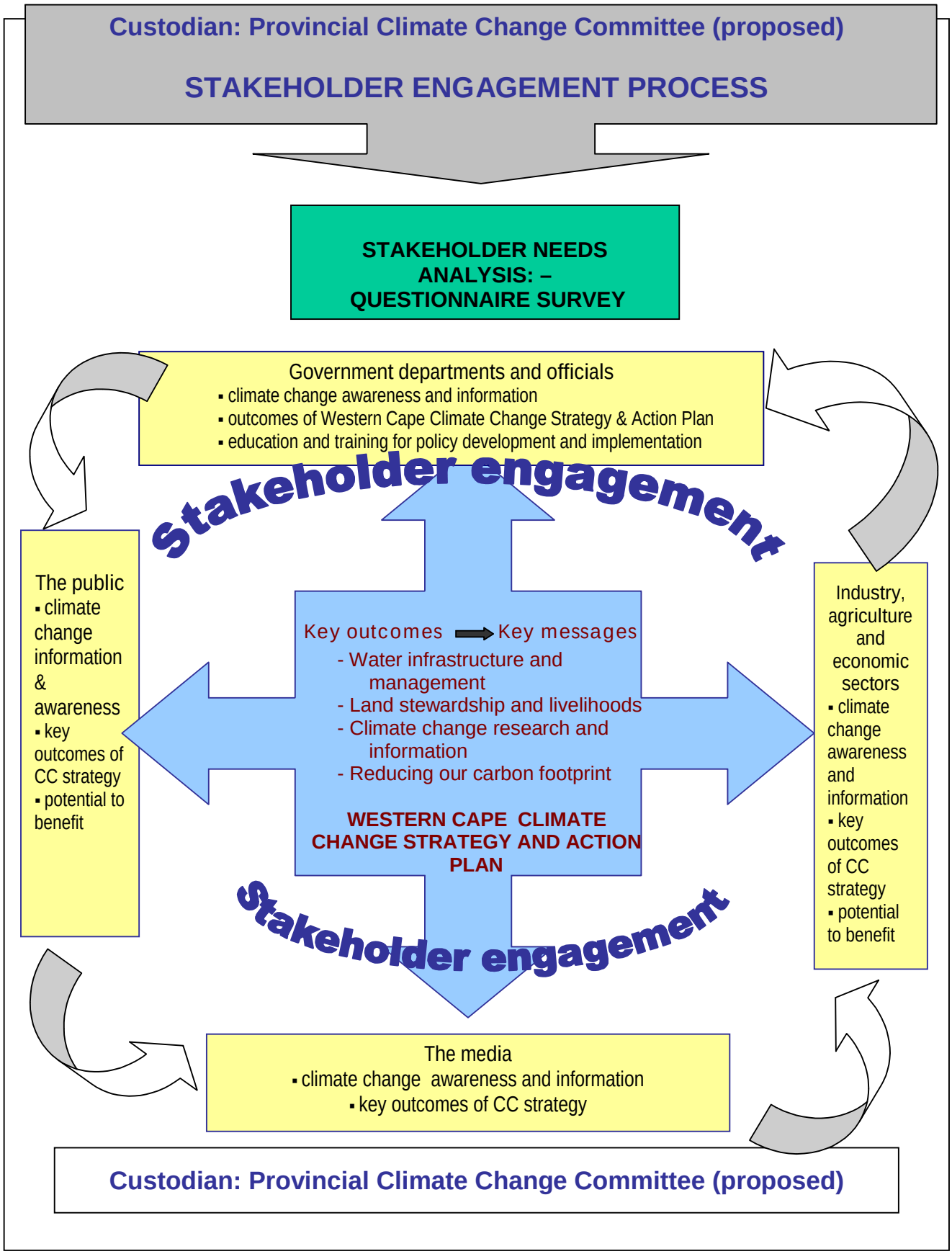
Audience		Type of information	Sample message/s	Level of detail
Local level (natural systems)	Biodiversity Water Coastal and marine	**Specific detailed and targeted information relevant to each sector:** ▪ Climate change impacts (detailed) ▪ Sources of relevant information (e.g. websites; brochures etc.) **Specific detailed and targeted information about adaptation/ mitigation responses relevant to sector:** ▪ The Western Cape Climate Change Strategy and Action Plan – relevant details and implementation	Given the uncertainties and complexities of response to these systems, monitoring is critical to inform adaptation actions.	**SPECIFIC DETAILED TARGETED INFORMATION RELEVANT TO EACH SECTOR/ RESOURCE/ DEPARTMENT/ COMMUNITY:** **EDUCATION AND TRAINING**

Source: OneWorld Sustainable Investments, 2007

Towards a Climate Communications, Education and Public Awareness Strategy for the Western Cape

Figure 12 shows an overview of the Climate Communications, Education and Public Awareness Strategy.

Figure 12: Climate Communications, Education and Public Awareness (CCEPA) Strategy



Custodian of the Western Cape Climate Communications, Education and Public Awareness Strategy and Action Plan

The suggested custodian of the climate change Communications, Education and Public Awareness strategy and programme is the proposed Provincial Climate Change Council (PCCC), which would very likely require the input and support of a full-time climate change communications manager. This post would entail logistical support to the PCCC in the form of managing outputs (e.g. training materials); organisation of meetings and training sessions; etc.

Response options chosen from the matrix

Table 5 shows the climate change response options that were chosen from the options matrix for inclusion in the Climate Change Response Strategy and Action Plan. The complete matrix of options can be found as Appendix 5.

Table 5: Response options chosen from the matrix

Sector			*Ref No.
Agriculture	1.	Secure reliable supply of fresh water for irrigation	A.1
Energy/Air	2.	Monitor air quality for early warning of pollution episodes	E.1
	3.	Strengthen and extend Air Quality monitoring network and capacity for early warning	E.3
Fisheries	4.	Research and monitor climate change impacts on fisheries	F.1
	5.	Research and plan Operation Management Procedures	F.2
	6.	Research options to mitigate social impacts of changed situation (fisheries livelihoods)	F.3
Livelihoods	7.	Strengthen and focus socio-economic data about vulnerable communities; develop scenarios	L.1
Tourism	8.	Research impacts of climate change on tourism demand and project growth	T.2
Water	9.	Research resilience of water supply, systems and infrastructure and susceptibility to extended drought	W.1; W9
	10.	Initiate science-government dialogue	W.2
	11.	Research methods for improving efficiencies of water use (not agricultural)	W.3
	12.	Research the efficiency of water use by agricultural sector	W.7
	13.	Monitor and evaluate water supply and demand	W.11
Energy/Air	14.	Set energy efficiency (EE) standards; incentivise EE programmes; implement targets; establish feed-in tariff structure	E.5
Water	15.	Increase water-efficiency through pricing strategies and awareness	W.6
Energy/Air	16.	Education regarding energy efficiency standards, measures and alternative energy sources	E.2
	17.	Create awareness and subsidised programme to displace paraffin and wood fuel burning in low cost areas	E.4
	18.	Education regarding alternative energy supply options (wind / SWH/ Natural gas)	E.6
Transport	19.	Public transport systems on cleaner fuels (LPG / LNG buses); Provide support to LPG taxi industry initiatives (Kulani Gas)	TR.2
Water	20.	Regularly produce and publish interpretations of climate projections	W.10
Agriculture	21.	Identify, monitor and control pests and diseases using IPM including fruit fly	A.2; A3
	22.	Extend weather station network	A.4
Biodiversity	23.	Fire management	B.1
	24.	Set up protected area along gradients/corridors of altitude, rainfall etc.	B.2
	25.	Rehabilitate river banks (fight floods)	B.3
	26.	Implement invasive alien species removal programme	B.5
Water	27.	Repair leaks and UAW	W.4
	28.	Remove invasive alien plants (IAPs) from the riparian zones	W.5
	29.	Implement the ecological reserve	W.8
Built Environ-ment	30.	Integrate CC factors into infrastructure planning – link to IDPs. Maintain in public domain or establish strong PPPs	BE.1
	31.	Establish robust building standards that incorporate CC and implement these	BE.2

	32.	Integrate CC into development planning and approval processes	BE.3
Built Environ-ment	33.	Map highly vulnerable areas (floodlines etc.) and implement development bans in highly vulnerable zones	BE.4
Livelihoods	34.	Factor livelihood issues into all aspects of Climate Change planning	L.2
Tourism	35.	Integrate climate risks into development infrastructure	T.1
Disaster Management	36.	Review DM processes and integrate climate change into planning	DM.1

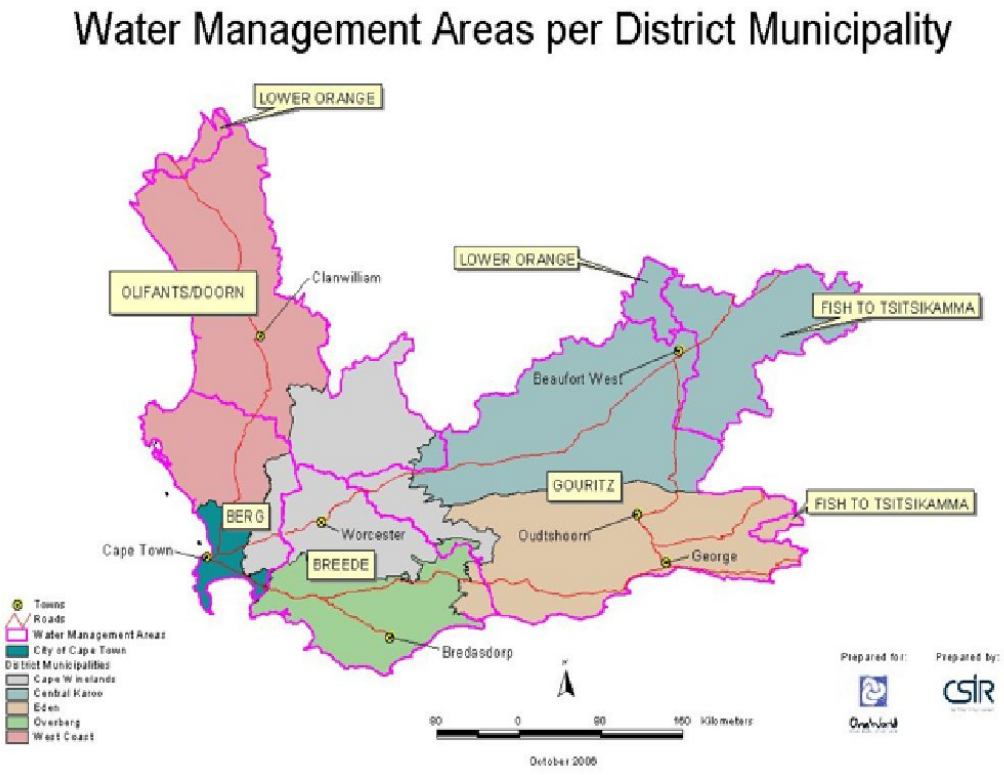
**Ref. No – This number refers to the reference number of the option in the main Options matrix.*

Spatial parameters

The Strategy and Action Plan has been developed with reference to the spatial parameters of the water management catchment areas (or Catchment Management Areas – CMAs) per district municipality. These areas can be seen in Figure 13. There are four CMAs in the Western Cape. From east to west, these are the Gouritz, Breede, Berg and Olifants/Doorn CMAs. These Catchment Management Agencies will be responsible for carrying out many functions that were previously the responsibility of the Department of Water Affairs (DWAF), focusing mainly on operational water management within the boundaries of the Water Management Agencies. It is envisaged that this will take place on an agency basis, either by delegated, devolved or assigned authority. DWAF would then regulate the CMA board to ensure that the government imperatives are being carried out to the benefit of all water users in each water management area.

The Breede River CMA was promulgated in 2005. The Gouritz and Olifants/Doorn CMA development proposals were scheduled to be approved by DWAF in 2006. The last of the CMAs to be established will be the Berg River CMA that will be subsidised towards the end of 2008.

Figure 13: Western Cape Catchment Management Areas (CMAs)



Adaptation Action Plan –

Adapting to the changing climate of the Western Cape

Adaptation, land stewardship, land use planning and strategic planning

Some climate change response actions in the Western Cape Climate Change Response Strategy and Action Plan, such as Integrated Invasive Alien Species (IAS) Management, have arisen directly out of changing circumstances brought about by climate change. However, these actions nonetheless build on programmes that already exist because of other identified needs – such as protecting eco-systems and biodiversity, and conserving water. Taking the IAS example further: whereas the programme initially has a strong plant invasives focus, this over time with climate change is likely to focus increasingly on microbial invasives. This is where targeted research is required to ensure a dynamic response strategy and action plan. Many aspects of the identified programmes (i.e. adaptation responses to climate change) are responses that build on existing plans and proposals within the province's existent activities, infrastructure and development planning. However, the effects of climate change make the necessity of the implementation of such plans much more urgent, and in fact essential.

In some cases it is critical that existing infrastructure be extended, for example the weather station network. Other necessities are the strengthening and maintenance of existing infrastructure, for example water infrastructure, where water leaks are believed to account for large amounts of wasted water, and repairing these systems will amount to significant savings, at a relatively low cost. Dwindling water resources under a new climate regime mean that these options must be taken very seriously.

Suggested adaptation and mitigation response programmes have also taken into account the need for sustainable development.

Adaptation Response Strategy and Action Plan Overview

Outcomes and objectives

The adaptation-based strategic response and action plan for the Western Cape is developed against the key strategic outcome of the Province's effectively adapting to an inevitable degree of climate change (regardless of current and future action to reduce greenhouse gas emissions) *through managing risks and minimising the negative impacts of climate change*. This will be achieved through inputs, activities and outputs that recognise that adaptation is vital and must start now. The strategic response and action plan are based on the following identified objectives:

- Coordinating the Western Cape's input into climate change adaptation strategies at national, regional and local levels.
- Pursuing economic opportunities from the province's innovative adaptation technology responses to climate change that are successfully developed and implemented.
- Ensuring that climate change risks are effectively integrated into development planning and approval processes.
- Ensuring that key resources such as water and fragile environments are conserved, protected and responsibly utilised.
- Supporting research into the impacts of climate change and related risks in the Western Cape and the development of innovative responses to climate change that can be replicated elsewhere.
- Working with and involving the community in responding to and adapting to climate change.
- Communicating all of the above objectives, as well as relevant climate change information and awareness, to all stakeholders and communities throughout the province.

Funding adaptation responses

Generally speaking, funding sources for ***adaptation*** in developing countries can come from three areas: private sector, public sector and international community flows (Bouwer & Aerts 2006). Private sector flows can come from flow of remittances, foreign direct investment, public private partnerships and market-based insurance mechanisms.

Increased Treasury allocation is one method of using local public sector funding to finance climate change response options. If Treasury does not allocate additional funds, then departments must fund implementation of the strategy through their current baseline (Hickey, pers. comm.). Other public funding sources include disaster management funding and risk reduction because extraordinary disaster funds are released by the State on certain conditions (for example, the declaration of disaster areas). A further option is the removal of perverse subsidies (such as the current practice of subsidising fossil fuel based electricity) to free up resources for climate change mitigation and adaptation, although this is more of a national level activity. Specific resource charges may also be proposed and the province could consider a provincial water levy additional to the existing national levy for research linked to water-related eco-systems.

International public sector funding flows are also possible through the international donor based community. Efforts to adapt to climate change would be more effective if integrated into this structure. Overseas Development Assistance (ODA) commitments to the Western Cape were R100 million for the 1994-1999 period – the second lowest in the country. Almost 90% of all ODA commitments were to national government.

Furthermore, there are several specific climate change and environment-focused funding options in support of *adaptation* in developing countries, such as the UNFCCC and GEF funds. Climate change issues and areas covered by these funds include vulnerability and adaptation assessments; concrete adaptation projects and programmes; and *adaptation* funding priorities focusing on any of the following: health, agriculture, water or vulnerable ecosystems.

The most critical source of funding to finance climate change response options is, however, still through Treasury. All of the responses and related action items prioritised in the response

strategy and action plan are items that either are or should be implemented even without the additional climate change argument. Factoring in climate impacts and the associated risks ensures that the action item receives the appropriate attention on one hand and a budget that allows for cost effective risk management on the other.

Applications for international climate change funding are stronger when there is local funding and commitment to action.

When considering budget applications and allocations for financing climate change response, Treasury should consider the cross-sectoral nature of climate change and the risks (and related costs) of inaction.

Recommendation

It is recommended that Treasury promotes its cross-sectoral budget allocation prioritisation and proactively encourages departments to use this platform when prioritising climate change related budgets. Provincial departments should also consider collaborative, cross-sectoral approaches in considering climate change impacts and associated risks.

Parts of the private sector are to some extent already factoring climate risks into their decision-making processes. The insurance industry (particularly re-insurers, such as Munich Re) are taking climate risks seriously in their actuarial modelling. This in turn influences insurance aspects such as premium calculations and costings.

Government needs to ensure that its own house is in order with respect to considering and guarding against climate risk. Government is a major owner and regulator of infrastructure in the Western Cape and South Africa, and a significant asset holder. As it self-insures its asset base and infrastructure, it runs at considerable risk. It also exerts a level of influence over private and community-based assets. Local government also controls and has responsibility for significant infrastructure investments such as roads and bridges. It falls to government to ensure that these assets are appropriately managed in accordance with the
potential threat posed to them by climate change and with due consideration to the costs to the community that would be incurred if the services they provide were disrupted or if development planning and approvals do not consider the climate risks.

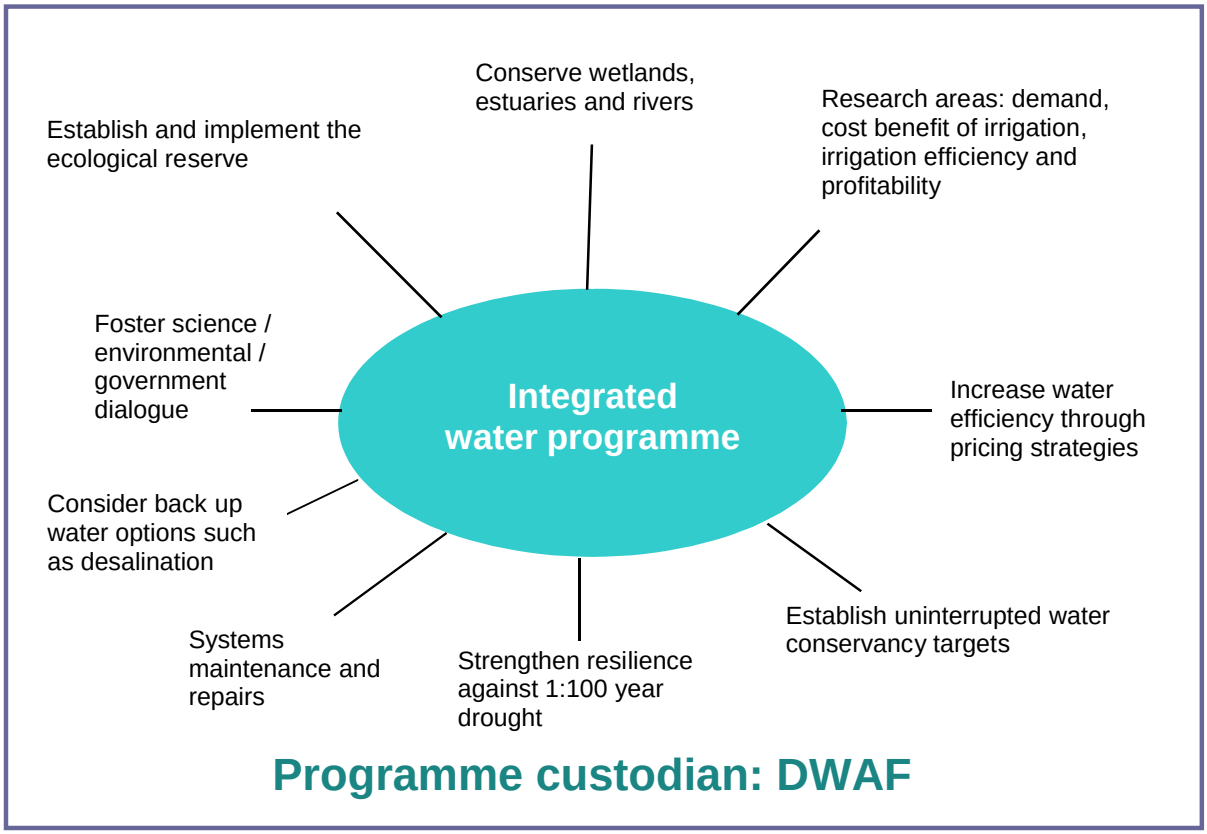
Strategic outcomes and related actions

Key outcome # 1

Establish a cohesive Water Supply and Infrastructure Management Programme that integrates climate impacts and risks

The Water Supply and Infrastructure Management Programme is an integrated programme comprising various components. Figure 14 illustrates the structure and components of the programme.

Figure 14: A cohesive water supply and infrastructure management programme that integrates climate impacts and risks



Source: OneWorld Sustainable Investments 2007

What is the challenge?

Existing scarcity, population and economic growth

Water is already a scarce resource in the Western Cape, and a number of challenges are exacerbating this situation. Water must be allocated and delivered to an expanding population: the Western Cape is experiencing rapid population growth (the population of the greater Cape Town area, including some West Coast towns, Boland, the Swartland and the Overberg) has doubled to ~3.2 million in the last 20 years. The Cape Town area currently has the highest net migration in South Africa and this is increasing water demands even further. The southern coastal area, from Hermanus to Plettenberg Bay, has also experienced rapid development. The availability of water is a constraining factor on further growth in this region. Average precipitation is less than current usage. Water resource studies are underway in the George area with a view to increasing supply in an area of rapidly increasing demand. Oudtshoorn is working on means of expanding its supplies and will probably rely even further on groundwater. There is marginal scope for the increased use of surface water resources and the size of available groundwater resources has yet to be determined all along the southern coastal area. In the Sandveld region north of Velddrif, heavy exploitation of groundwater for agricultural purposes is causing groundwater levels to drop rapidly and there are threats of seawater incursion into the local aquifer.

General economic growth has increased demands for water. The national goals of about 6% economic growth, targeted so as to reduce high levels of poverty in the country, require that the major metropolitan regions grow at even faster rates (of, say, 8%). Water shortages must furthermore be considered in the context of current and planned economic development in the region. Furthermore, 50% of South Africa's exported agricultural produce comes from the Western Cape, with all high value crops being irrigated. Demands for irrigation water are intensifying as investment in agriculture continues.

Unmet Ecological Allocations

In every river system, some water has been reserved by law (the National Water Act; 36 of 1998) for the maintenance of ecological functioning of rivers, wetlands and estuaries. Maintenance of aquatic ecological diversity and ecosystem functioning is important because there are valuable forward and backward economic linkages to wetlands and estuaries, for example ecotourism and coastal fisheries (apart from other social and cultural values). This reserved water is known as the Ecological Reserve and, along with the Human Basic Needs Reserve, has the highest legal priority as a "user" of water in a river, above industrial and agricultural use.

The Ecological Reserves of the aquatic systems are being determined through scientific investigation but are not being met by the appropriate water allocations. The simple reason is that there is not enough water in the river systems at present to meet all demands by irrigation, urban/industrial and ecological needs.

Diminishing Supply Options

Options for large new bulk supplies (big schemes such as the Berg River scheme now under construction) are limited because the major resources have already been developed. Options for further water resource development do exist. Briefly, these are listed as:

- An inter-basin transfer from the Breede CMA to Voelvlei dam, but this presents environmental difficulties regarding pipeline routes.
- The Palmiet River also constitutes an environmental issue in terms of the Kogelberg Biosphere reserve.
- Diversions on the Eerste and Lourens rivers have water quality problems.
- The Cape Flats aquifer is of limited resource size and in some areas has potential for problems of water quality.

- The potential capacity of the Table Mountain aquifer is very large but its capability for supplying sustainable quantities of water that are not also environmentally damaging have yet to be determined.
- Desalination is an expensive option. At present, water can be provided at a cost of more than four times that of runoff-based water supply schemes. Even as an emergency option, it will cost several hundred million Rand for a contribution of ~5% to the total daily water demand of the City of Cape Town as it is a relatively heavy user of electrical power.
- Recycling is an option that has been poorly utilized to date, possibly because of concerns regarding water quality. It probably has the greatest potential for increasing supplies in the Cape Town metropolitan area.

By 2030, if water demands continue growing at between 2% to 3%[20] a year, there will be an annual shortage of about 230 million m^3 under normal climate conditions in the Western Cape Water Supply System (that supplies the greater Cape Town region).

Losses and inefficiencies

The City of Cape Town is purported to be losing about 32-33% of its supply in ***Unaccounted for Water (UAW) and water leakages***. Unaccounted for water is that water lost in the system between supply and user but with no indications of where the water is going missing. UAW accounts for about 17% of the total. Leaks as a result of pipe bursts and damaged water supply infrastructure comprise the other 15%.

However, water is also inefficiently used with much going to waste through automatic-flush sanitation systems and inappropriate watering of gardens and fields. Such waste and inefficient use may total a further 24% of the total water supply to the greater Cape Town area.

Institutional issues and communication

The institutional arrangements in managing a critical natural resource in South Africa are not always clear or consistently implemented. The relationships between DWAF, provincial government, the recently established CMAs and Local Authorities sometimes create conflict and confusion since accountability is not clearly demarcated. DWAF has a regional function but not a provincial line function.

Cheap water

Water prices in South Africa are amongst the cheapest in the world and consumers are not respectful of water as a scarce resource (similarly to the case with electricity). The scarcity and relative value of the resource as an essential requirement to all aspects of human and economic life is not factored into the price South Africans pay.

Water allocation reform and water for poverty reduction

The government of South Africa is looking for means of reducing poverty in the country. Irrigated agriculture has been identified as one possibility. Given the total commitment of water to existing allocations, the government is looking to a programme called Water Allocation Reform (WAR) as a means of sharing water with a wider section of the population. A pilot project is underway in the Western Cape. However, there are also concerns in government that objections to new allocations of water on environmental grounds have racial connotations. The issue is sensitive and needs plenty of dialogue between the different stakeholders.

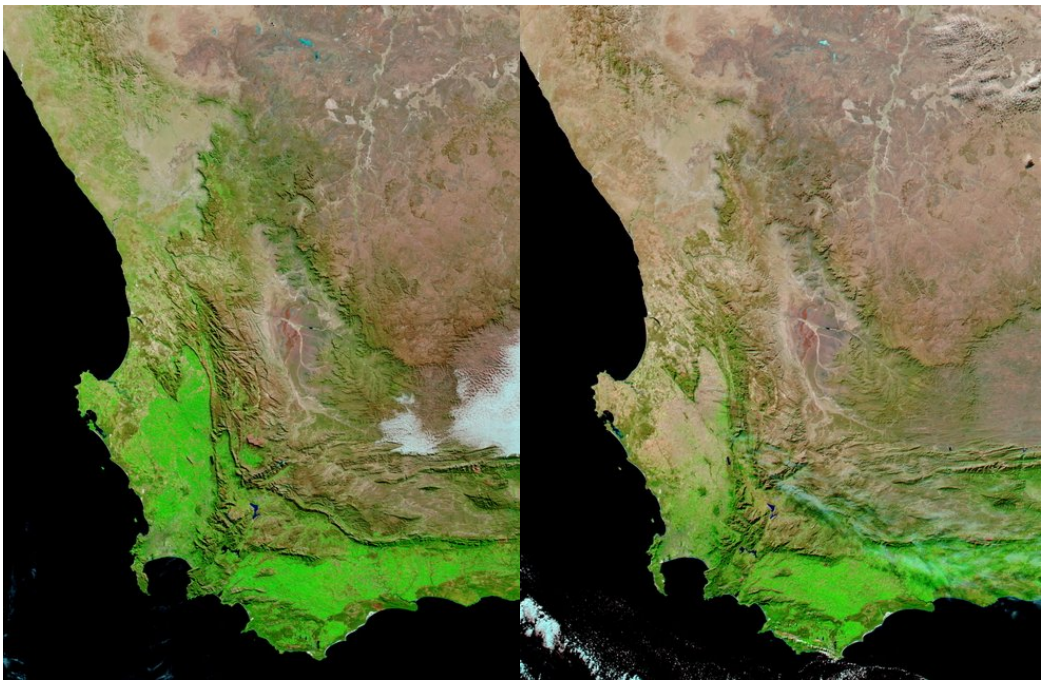
Resilience of the Western Cape Water Supply System

[20] On the basis of DWAF projections for water demand for 2006, 2010, 2030, etc.

The resilience of the Western Cape Water Supply System to an imposed shock, such as a five-year drought, is not well understood. Because of the increasing water demand in the region, a recent three-year drought brought reservoir storage to critical levels. Five-year droughts have been known to occur and such an event in the future will have severe economic and social consequences for the region.

Parts of the province have demonstrated a good response to water restrictions (particularly Cape Town) and this ability to respond indicates a measure of elasticity in the system.

Figure 15: The satellite photo on the left shows a normal biophysical profile of the western part of the Western Cape during normal winter rainfall (21 July 2002). The right-hand photograph shows the situation on 21 July 2003 under drought conditions.



Climate change-induced complexity

Finally, climate change projections for the region indicate a drying in the south-western parts of the region. It is likely that the winter rainfall season will become shorter and rainfall totals less. These projected trends will add a layer of increased complexity and difficulty to the sustainable management of the region's water resource utilisation.

A key issue with climate change-induced rainfall reduction is that the effect is amplified in the change of runoff. A mountain research catchment at Jonkershoek near Stellenbosch has recorded a decrease of 14% in rainfall since 1945 to the present day, which translates into a 20% decrease in annual runoff. Relatively small changes in rainfall can have large implications for runoff. This is of special significance in a region of relative water scarcity.

The challenge therefore is to increase water resource and infrastructure management skills in the light of increasing demand on the one hand and a climate change-induced decline in the resource availability on the other.

What is the solution?
Water is the province's most significant risk in the context of climate change and an integrated response approach is essential. This response should incorporate the following aspects:

Water efficiency needs to be improved in all sectors, including agriculture. The City of Cape Town has an existing water demand management strategy with a target to reduce demand in Cape Town by 20% or more by 2010 (DEA&DP 2005). Water restrictions, block tariffs and user education on water efficiency have already begun. According to the City of Cape Town (2002), a total of 220 million m^3 can be saved or supplied at a maximum cost of R1.45/m^3. The ongoing water 'reconciliation study' needs to update these figures, make assumptions explicit, and include sensitivities to climatic variability and longer-term climatic changes in the Western Cape. The study also needs to be supported by detailed research on where efficiencies can be achieved at the lowest costs.

This aspect also entails maintenance, repairs and efficiency programmes and processes that aim to utilise the water the province already has at its disposal as efficiently as possible.

Government-science interaction
In order to address climate change appropriately, ***an ongoing platform is required that facilitates dialogue between climate scientists and government***. Given the urgency of the water resource management problem in the Western Cape and the important implications of climate change for this problem, it is imperative that a core group of scientists are capacitated to meet with government on an annual basis in order to share information about the impacts of climate change on water resource management. This discussion platform will facilitate the necessary flow of information between scientists and government that is needed in order to address research requirements, planning and other preconditions for appropriate adaptation options to be put forward. Two immediate needs are:

- Research funding to support the climate change knowledge base – i.e. ***targeted research*** that aims to answer key questions identified in support of the implementation programme.
- The establishment of an information system (database) and communication network to facilitate provincial and nationwide response (e.g. freely accessible climate change information for farmers in newspapers and on the internet).

Both these aspects deserve to be part of a generic response to climate change that includes research, communication and an awareness campaign also including other sectors (such as agriculture).

Strengthening resilience
This aspect entails strengthening water supply and system integration, i.e. monitoring demand and supply by all sectors, researching options and reducing waste as well as researching and increasing human and economic adaptive capacity to droughts to include the likelihood of the occurrence of a 1:100 year severe drought as experienced in the 1920s. Water-efficiency must be increased in agricultural, industrial and domestic consumption. The introduction of a regulatory framework for water would support this.

Securing alternative supply
This aspect requires the development of alternate water supply options such as harnessing seawater through desalination – particularly as a reserve or 'back-up' supply.

- Recycling is a very important option but one that requires further research, including into aspects of social perceptions and levels of acceptability around this issue.

- Utilisation of the Table Mountain Aquifer (groundwater) is an option being researched. It is unknown at present how much water could be extracted from this large aquifer system.

Actions

- ***Implement the ecological reserve*** and equip CMAs to deal with the projected impacts of climate change on their respective catchments. This includes the development of a research and a planning manual that will guide decisions on climate-induced events.
- ***Budget for systems maintenance and repairs*** and ***create accountability*** within the relevant authorities such as Cape Town City for ensuring that programmes such as leak repairing are implemented and monitored.
- ***Establish uninterrupted water conservancy targets*** to achieve 15% water efficiency across sectors by 2014 supported by a water feed-in tariff (FIT), which needs to be evaluated as an option. The costs, benefits, risks and opportunities of this tariff to the economy and people of the Western Cape need to be made explicit in any future strategy.
- ***Research*** is needed on the likely change in demand due to changing water prices and the ability of consumers, especially irrigation farmers, to absorb the cost of implementing water-saving technologies. This research would also inform incentive structures or alternate financing mechanisms for more efficient irrigation technologies to be used by emerging farmers.
- ***Research on a comprehensive calculation of costs*** to make up the shortfall of all existing and projected economically feasible irrigation schemes in the Western Cape and the impacts of climate change on these shortfalls. Such a study on the profitability of irrigation farms in the face of rising water tariffs should take into account demand-side factors such as increased irrigation efficiency and increased plant water use. This is currently an existing focus area of the provincial Department of Agriculture. The recommendations from these studies will filter into further decision-making on water supply and demand options in irrigation agriculture.
- ***An analysis of the cost-benefit of irrigated agriculture*** (farm-level income and multipliers per litre of water used). This should distinguish between export and local-market driven production. This would feed into a scenario-based analysis of the Rand/litre value of these sectors, and thus socio-economic implications should irrigated agriculture experience a decline due to either supply short-falls or policy-driven decisions on allocation.
- Create a forum or platform for a dialogue between scientists and government to allow efficient research, management of water resources and communication of other aspects of climate change.

Box 3: Perth, Australia: Adapting to a reduced water supply

Perth, Australia: Adapting to a reduced water supply

South-western Western Australia provides an interesting and useful case study in the context of the Western Cape: the region has similar location (west) and latitude, with consequently relevant climate change attributes. The region has experienced a sudden drastic decrease in winter rainfall of roughly 15%-20% since the mid-1970s (Pitman *et al*. 2004), as can be seen in Figure 16. This change has strongly affected water supplies and related ecosystems (Sadler 2003), reflected in a 42% decline in inflow into the Perth metropolitan reservoirs. Average stream-flows of the last quarter century in Perth's water catchments are approximately 50% below those of the earlier part of the century. The 2001-2002 winter sequence represents the worst two-year drought on record and forms part of an eight-year sequence (1997-2004).

The water shortage of 2001-2002 prompted investment into new water sources and a two-day-a-week sprinkler regime to help conserve water. The State Government also established a task force to oversee a strategic response and to advise government on 'Our Water Future'. This process included public workshops culminating in a Water Symposium and led to the formulation of a State Water Strategy for Western Australia, released in 2003. The objectives were to improve water use efficiency in all sectors and to set targets, which included a 14% reduction in consumption per person per year (i.e. 155kL) by 2012 for domestic consumers in Perth; establishing a 20% reuse of treated wastewater by 2012 and requiring water conservation management plans for large water users. Some of the measures employed to achieve the targets are:

- *Domestic water demand management measures*: Garden watering restrictions, a demand management program incorporating waterwise initiatives, communications and marketing campaigns, a government rebate programme, stepped pricing structure and support to major non-residential customers for improved water efficiency.
- *Increasing water efficiency in agriculture*: A review of irrigation activities was conducted to establish the amount of irrigation water supplied and used, the benefits generated, likely future water needs and benefits and opportunities for improving efficiency. A farm waterwise programme is being delivered by the Department of Agriculture.
- *Promoting water reuse*: A regulatory framework has been established as well as trial projects and a communication and marketing strategy. The AU$28 million (approx. R162 million[21]) Kwinana Water Reclamation Plant (KWRP) became operational in late 2004, treating about 24 million litres a day of secondary treated wastewater. This reduces industry demand for water supply scheme water by up to six gigalitres a year.
- *Developing new resources:* The Water Corporation accelerated a detailed source development plan. The 2001-2002 drought required additional investment, taking the total investment to AU$665 million (approx. R3.8 billion) in a decade (Water Corporation website). During this period, supply capacity has been doubled and various water resources have been developed including a desalination plant, now Perth's largest single source of water, which supplies 17% of the city's needs. (Capital cost: AU$387 million - approx. R2.2 billion. Potential cost for households: AU$44 - approx. R250 per year).
- *Financing research and including results in planning*: A foundation was established in 2003 with a budget of AU$3 million (approx. R 17 million) from the State Government. In 2005, a second round of grants was issued totalling AU$ 3.1 million (approx R17.9 million). *[The full case study can be found as Appendix 2 to this report.]* Source: Summary - OneWorld

[21] At a rate of $AU1 = R5,78

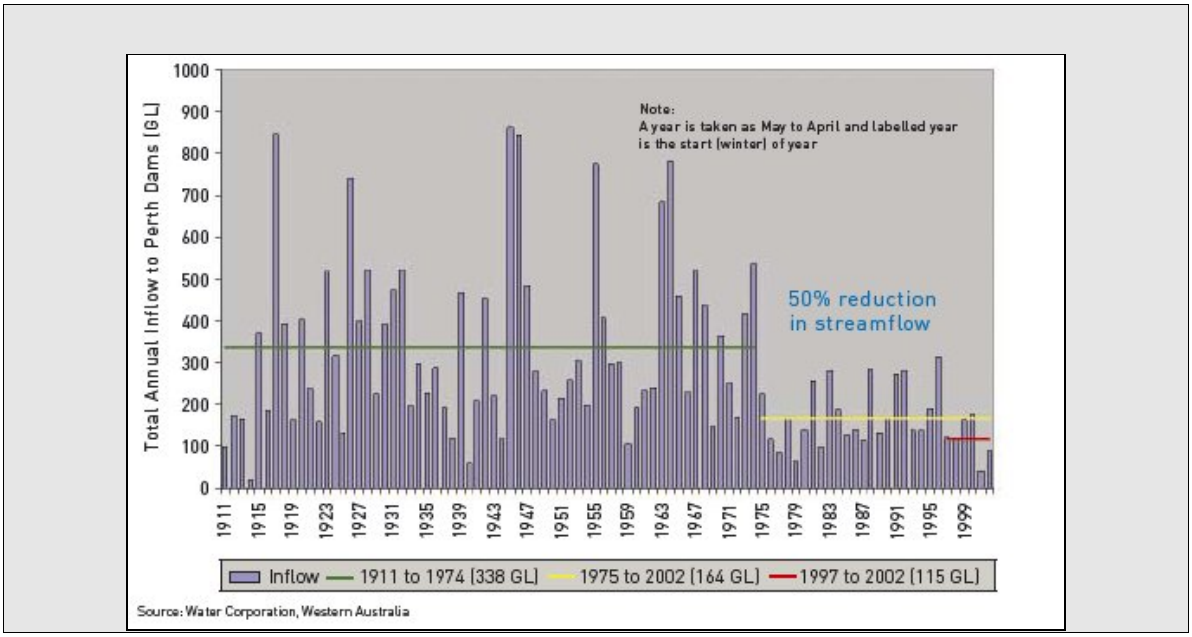


Figure 16
: Annual stream-flow into Perth's water supply dams, with averages before and after the rainfall decrease of about 10-20% (depending on location), which occurred in 1974-1975. Note that the decrease in water supply is about 50%. SOURCE: Water Corporation Western Australia

Suggested action custodian: DWAF

Action plan

Action:	**Responsibility**
• Establish a Water Group and co-ordinator at a provincial level and a Programme Steering Committee (PSC) that is representative of DWAF, DoA, the Disaster Management Unit, Local Authorities, communities and industry	**DWAF** as lead, with DEA&DP and CapeNature; DoA. The existing Provincial Liaison Committee, run by DWAF can be given this mandate
• Establish a cohesive and integrated vision and targets for water management at a provincial level and develop related Terms of Reference	Co-ordinator, with the PSC
• Build capacity in the relevant CMAs	DWAF
• Develop a research and planning manual	DWAF
• Map out municipal water supply systems, with storages and linkages and drawdowns • Map out irrigated agriculture, with crops and water supply systems (off and on-farm) • Develop financial model of irrigated agriculture • Develop drought scenarios • Model impacts of droughts and timing and costs of back-up response options such as desalination, wastewater treatment and the use of the aquifer.	Co-ordinator with relevant departments
• Research and verify extent of losses	Consultants
• Set targets – e.g. reduce water leaks and UAW to 15% by 2010. Monitor and validate this through research in order to quantify water savings in context of new supply	DWAF / Premier's office

systems.	
• Allocate responsibility and create accountability [22]	DWAF / Premier's office
• Secure appropriate budget	DWAF / Treasury
• Communicate the programme and outcomes	DWAF Communications department / PCCC / Premier's office
• Monitor effectiveness	DWAF / PCCC
• Establish and communicate water efficiency targets – 15% by 2014	DWAF
• Establish an appropriate pricing strategy / tariff structure	DWAF / Treasury
• Establish a fund into which the environmental tariff should flow – a Western Cape Fund	DWAF / Treasury
• Appoint a fund manager and establish criteria for fund disbursements – for example, research into capacity for water supply back-up and establish whether or not this back up supply could come from a desalination plant	DWAF / Treasury
• Communication, education and awareness	DWAF communications department and PCCC
• Establish clear monitoring platform – of water efficiency levels in all sectors and fund management	PCCC
• Create a science-government platform for discussion and formulation of needs for water-related requirements (e.g. research requirements; information database; awareness campaigns)	Co-ordinator / PCCC

Cost Effective Analysis

Repairing leaks and reducing water loss

The Water Services department of the City of Cape Town (2002) estimated that capital costs to the amount of R45 million is needed to fix leaks at an estimated unit reference value (URV) of R0.19/m^3, saving an estimated 15 million m^3 of water per annum (CCT 2002). This amounts to an annualised value of R2.8 million per annum. This figure may change due to updated costs estimates on leak fixing and gains made so far. Leak fixing is one of the lowest cost options available after the elimination of automatic flushing urinals (R0.15/m3) and the lowest costs private boreholes (R0.04/m3) and lowest cost grey water systems (R0.02/m3) (see Table 6) (City of Cape Town 2002).

[22] DWAF does not have a provincial function. The Premier's office is drafting an integrated water plan for the Western Cape with DWAF input.

Table 6: Cost of water management options in the City of Cape Town

Option	Savings (Mm3/a)	Capital Costs (Rm)	URV (R/m3)
Grey water use (low)	0.5	R4000/home	0.02
Private boreholes (low)	1.5	R2500/wellpoint	0.04
Eliminate automatic flushing urinals	4	10	0.15
Leakage repair	15	45	0.19
Pressure Management	17	55	0.24
Water-efficient fittings	10	50	0.31
Lourens River Diversion	19	35	0.46
User education	10	5	0.5
Voelvlei Augmentation: Phase 1	35	72	0.53
Treated wastewater to local urban irrigation and industry	11	96	0.8
Table Mountain Group Aquifer	70	530	1
Eerste River Diversion	8	77	1.06
Cape Flats Aquifer	18	162	1.13
Private boreholes (high)	1.5		1.45
Treated wastewater exchange with irrigation	5	96	1.62
Grey water use (high)	0.5		2.37
Treated wastewater reclaimed to potable standard	46	864	3.1
Desalination of seawater	na	850	8.59
Tarif, metering and credit control	10	na	na

Source: City of Cape Town (2002)
Notes: URV = Unit Reference Value

Implementing the ecological reserve

The delegated responsibility for implementing the ecological reserve lies with the evolving catchment management agencies (CMAs). CMAs for Gouritz and Olifants-Doorn have been established, while a CMA for the Breede is still in proposal phase. For the Berg no CMA nor proposal is existent yet (see www.dwaf.gov.za). Proposed annual costs for running the CMA in the Breede amounts to R30 million per annum, but this includes R19 million per annum outsourced to Working for Water (DWAF 2004).

Water efficiency in agriculture

The Food and Agriculture Organisation of the United Nations states that the *cost of installing irrigation systems is highly variable, but as a rough guide the annual cost for the farmer, which would pay for water, maintenance and administration of a scheme, varies from US$300/ha to up to US$1 300/ha under exceptional circumstances*. Furthermore, *accepted design efficiencies for the main irrigation techniques are as follows: a) 55-65 percent for surface irrigation; b) 75-85 percent for mechanized and non-mechanized sprinkler systems; and c) 85-95 percent for localized irrigation. Actual efficiencies seem to deviate from the default design values, although very little reported data are available to substantiate this. Surface (borderstrip) irrigation system efficiencies have been measured at 40 percent and up to 95 percent in a very few cases. One study indicated an overall efficiency of about 63 percent on some of the bigger irrigation schemes* (FAO, 2005).
NOTE – The above figures exclude the direct capex costs of conversions to efficient irrigation.

The Deciduous Fruit Producers Trust have conducted research and estimate this figure (annual cost of water, maintenance and administration of an irrigation scheme) to be R15 000/ha for the Western Cape.

Monitoring of water supply and demand
The monitoring and evaluation of water supply and demand is part of the responsibility of the evolving catchment management agencies. The unit cost for monitoring and evaluation of the weather network is used as a proxy (see following option).

Suggested action custodian: Catchment Management Agencies (CMAs); DWAF.

Environmental, Social & Livelihoods Impact
Repairing leaks that occur between the point of monitoring where water comes into households and its use is very important in reducing water bills, particularly in poor households. This action, if expanded to individual households, therefore reduces unnecessary water wastage and contributes to poverty alleviation. Environmental Monitoring Group has conducted a study on this topic as a means of adapting to climate change whilst addressing poverty alleviation because many households are unable to afford their water bills when there are leaks in the system causing higher 'consumption' of water.

As with ***energy efficiency and pricing strategies***, it is important that the poor are protected through differential tariff structures. Although households already receive free water, it is important that further economic and social productivity is not compromised because of an inability to afford basic water.

Future ***research*** in water efficiency should have an additional focus on efficient water use in small-scale agriculture and in low-income houses. Many small measures can help to reduce water consumption and it is important that people are educated about these so they may be effectively implemented. It is also important to explore irrigation options that are more efficient and better-suited to small-scale farmers. Farmers frequently take part in development projects to set up irrigation schemes but if the irrigation system is not efficient and cannot be maintained it can contribute to increasing vulnerability. On the other hand, efficient low-technology irrigation schemes such as drip irrigation can be used to reduce the vulnerability of small-scale farmers to increased temperature and rainfall variability.

Agriculture irrigation: Capital investment costs are often a problem for emerging and cash-strapped farmers, yet these individuals are generally the ones that need the changes to make them more competitive, given the small margins within which they operate. Finding ways of transferring more efficient technologies to these groups at low cost is therefore an important adaptation option in enabling farmers to adapt to increased water stress.

Brief Summary
Climate change reinforces the need for enhancing institutional capacity in catchments and clearly defining water rights and the rules on which allocation of water takes place. The additional direct costs of climate change on the management of the basin is difficult to quantify but it is safe to state that increased water scarcity due to reduced supply and increased demand (New, 2005) does reinforce the need for effective management of the resource.

Key outcome #1: Options included from the matrix:

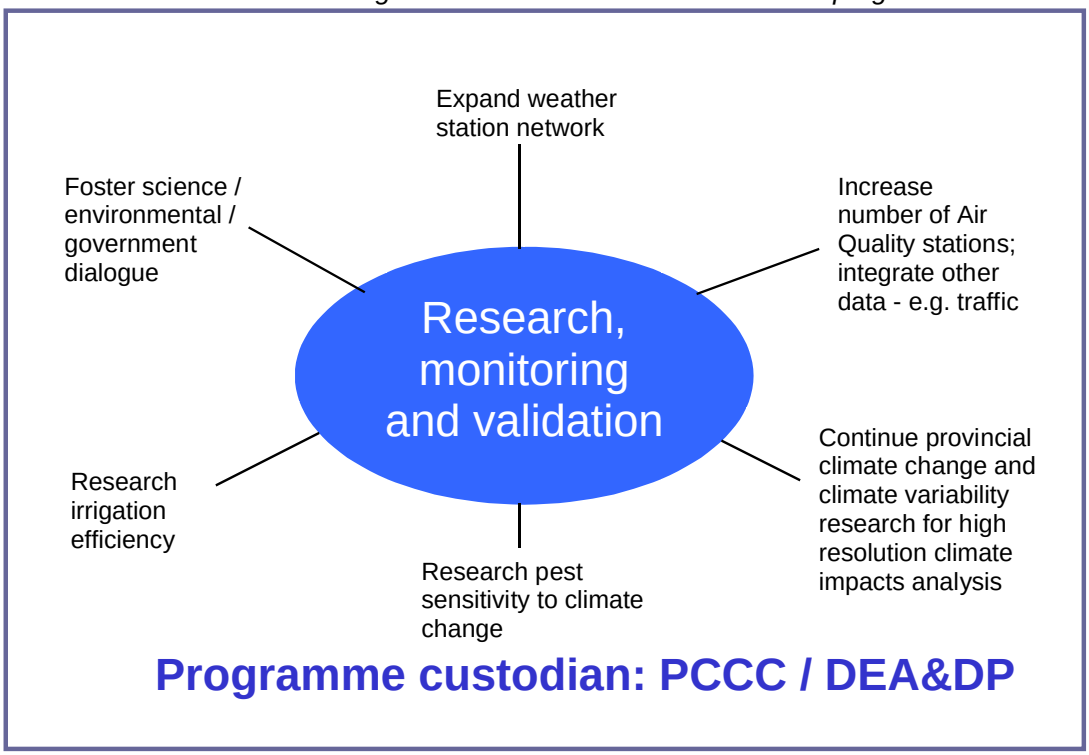
- Water (W4): Repair leaks and reduce water loss by 15% by 2014 Estimated Cost: R2.8m per annum NOTE: This is based on information that is out of date. These costs are subject to further review and better information
- Water (W8): Implement the ecological reserve Cost: R1.3 million, 5 years – research costs
- Water (W6): Increase water efficiency – promote water management and change behaviour toward water as a resource through pricing strategies Cost: R1.3m pa, 5 years – probably needs revision
- Water (W11): Monitor and evaluate water supply and demand Cost: R600K capital, R800 pa
- Water (W1; W9): Research resilience of water supply, water systems and infrastructure, and susceptibility to extended drought, and improve resilience Cost: R1.3m pa, 5 years

- Water (W3): Research and improve water-use efficiency in all sectors (excluding agriculture – see W7) Cost: R1.3m pa over 5 years
- Water (W7): Research efficiency of water use by agricultural sector

Key outcome # 2

Establish a focused climate change research and weather information programme

Figure 17: A focused climate change research and weather information programme



Source: OneWorld Sustainable Investments 2007

The programme comprises two components:

- **Extend the weather station network**
- **Regularly produce and publish interpretations of climate projections (relevant to all sectors) *Cost: R500K pa, 3 years***

What is the challenge?

The Western Cape is home to a number of weather stations, some of which are monitored. The network is however not robust nor is it consistent across the region and finer scale forecasting needs to be well disseminated to inform farm management decisions, early warning systems in terms of extreme events and long term disaster prevention / management such as extended droughts. It also provides better baseline estimates for research purposes.

Monitoring weather and climate change

Reduced rainfall, increased temperature and increases in extreme weather events are some of the climate changes anticipated in the Western Cape. Fine scale, consistent weather forecasting for the agricultural sector provides information allowing better correlation of production with changes in climate variables. This could lead to improved product quality. Climatologists can also use the data in their climate modelling to assess climate changes at a local level at higher resolution.

What is the solution?

A total of 25 additional stations are required for the province and the weather station network can be extended to reach the targeted 25 additional stations by 2008. A budgetary allocation for building the required 25 weather stations (R24 000 per station) is required, as is training of human resources and ensuring sufficient budget allocation for the maintenance of existing weather stations. The resource capacity must include the dissemination of data to the appropriate stakeholders and users timeously and consistently.

Suggested programme custodian: The Department of Agriculture

Action Plan

Action:	Responsibility
▪ Allocate the budget on the basis of 14 stations for the 2007/2008 financial year and 11 for the 2008/2009 financial year	Department of Agriculture (DoA) and Treasury
▪ Establish the channels for communicating weather information	DoA communications department with the PCCC; Provincial Disaster Management Unit and Local Authority Emergency Services
▪ Establish the platforms for collating weather data and analysis thereof in the context of climate change indicators	DoA / PCCC / CSAG? (to be determined)

Cost Effective Analysis

A weather station costs approximately R20k in capital costs and installation, with an additional R4k for civil site works, and R2k on maintenance per annum. An additional 25 stations are required. The human resources needed include one provincial climatologist at an estimated salary of R300k per annum and three technicians at R100k pa each[23]. Total capital costs therefore amount to approximately R600k with annual operational costs amounting to R700k before capital provision. At a rate of 10% depreciation, annual costs amount close to R800k per annum.

A detailed cost breakdown is as follows:

Weather Station	*R 24 590 per station*
Basic unit (Vantage Pro II)	R 6 700 per station
Software	R 1 860 per station
UV Sensor	R 3 950 per station
Solar Radiation Sensor	R 1 800 per station
Mounting	R 280 per station
GPRS	R 2 000 per station
Installation	R 2 000 per station

[23] Johnston P, personal communication, Hewitson B, personal communication

Civil site works	R 4 000 per station
Maintenance	R 2 000 per annum

The capital investment and running costs of improving the weather station network yields significantly higher benefits than retaining the status quo. The value of early warning systems to emerging and commercial farmers, local authorities, the Disaster Management Unit and the public in terms of extreme events and to researchers who monitor and project climate changes dynamically is immeasurable. The costs to the provincial infrastructure and the social costs of known recent extreme weather events speak for themselves.

Environmental, Social & Livelihoods Impact

There is no direct impact on livelihoods of extending the weather services network but there are significant indirect impacts derived from early warnings to farmers for example. A better understanding of weather systems and their contribution to early warning systems has a considerable social benefit if relevant information is given to those who need it early enough to allow for related planning.

Key outcome #2: Options included from the matrix:

- A4 Extend the weather station network (Agriculture A4)
- Regularly produce and publish interpretations of climate projections (relevant to all sectors) All sectors (W10): 3.1.19 Cost: R500K pa, 3 years

Key outcome # 3

Establish clear linkages between land stewardship, livelihoods and the economy

In 2003 the bulk of the Western Cape's water was used in agriculture, households, the built environment and industry (commerce and manufacturing), as shown in Figure 18.

Responsible and efficient stewardship programmes aim to protect the Western Cape's valuable eco-systems, water quality and resources – with significant livelihood and economic impacts. Government has a clear role in protecting community interests and assets for which market valuations do not always exist but which are nevertheless valuable to the economy, community well-being and livelihoods.

Evidence has shown that protection of invaluable environmental resources that are hard to replace proves to be far cheaper than other options. Protection of fragile environments also indirectly provides a safety net for vulnerable communities and livelihoods since the destruction of these areas usually comes at a far greater cost than is initially estimated, with vulnerable communities usually hardest hit by such costs.

Figure 18: Water use by sector and by Catchment Management Area (CMA) as of 2003, of the four CMAs covering the majority of the Western Cape Province (Source: BKS 2003a, 2003b, 2003c and 2003d).

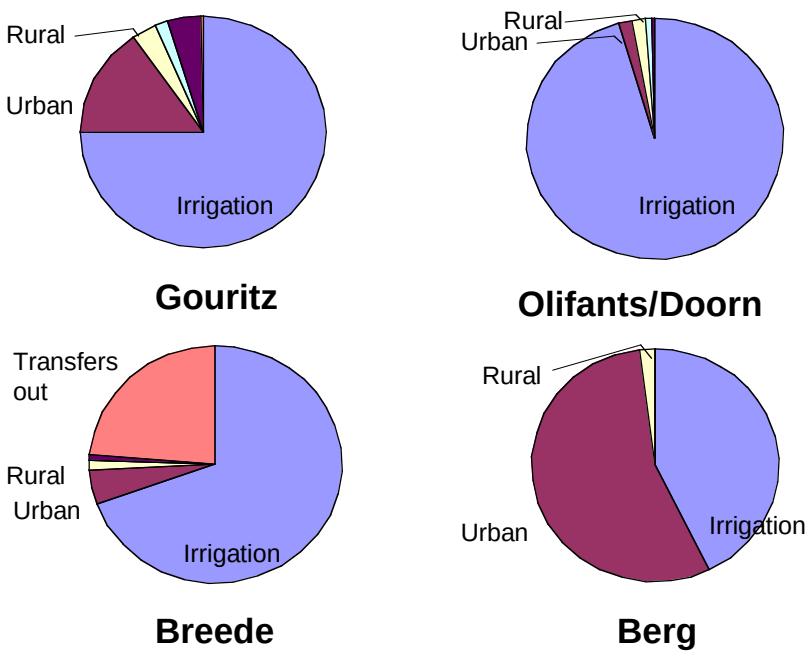


Figure1.11 Water use by sector and by Catchment Management Area (CMA) as of 2003, of the four CMAs covering the majority of the Western Cape Province (Source: BKS 2003a, 2003b, 2003c and 2003d).

Damage to the environment** in the face of climate change will inevitably cause **loss of jobs**, reduced circumstances in terms of **health and hygiene** and **increased costs of services

Natural systems have no ability to plan for climate change and are solely reliant on their natural adaptive capacity. For species that come under significant pressure from climate change this is unlikely to be sufficient to ensure their survival. Localised pressure and human activities increase the risk.

All rivers, wetlands, estuaries and groundwater systems have intrinsic value. Protecting them supports ecosystems and ensures water for use and biodiversity. Catchment management plays an extremely important role in preventing resource degradation. Best practice catchment management requires working with landowners, the community and water users to understand catchments and implement systems and actions to maintain and in some cases, to restore water quality and other values of healthy catchments.

Primary resources – land (agriculture), water, fisheries – play a vital role in the economy of the Western Cape. It is imperative that on one hand the province protects these resources, and on the other, proactively develops and manages them sustainably. This imperative implies the initiation of land stewardship-based programmes that link directly to sustainable livelihoods and economic growth.

Developing and managing resources

for a vibrant economy

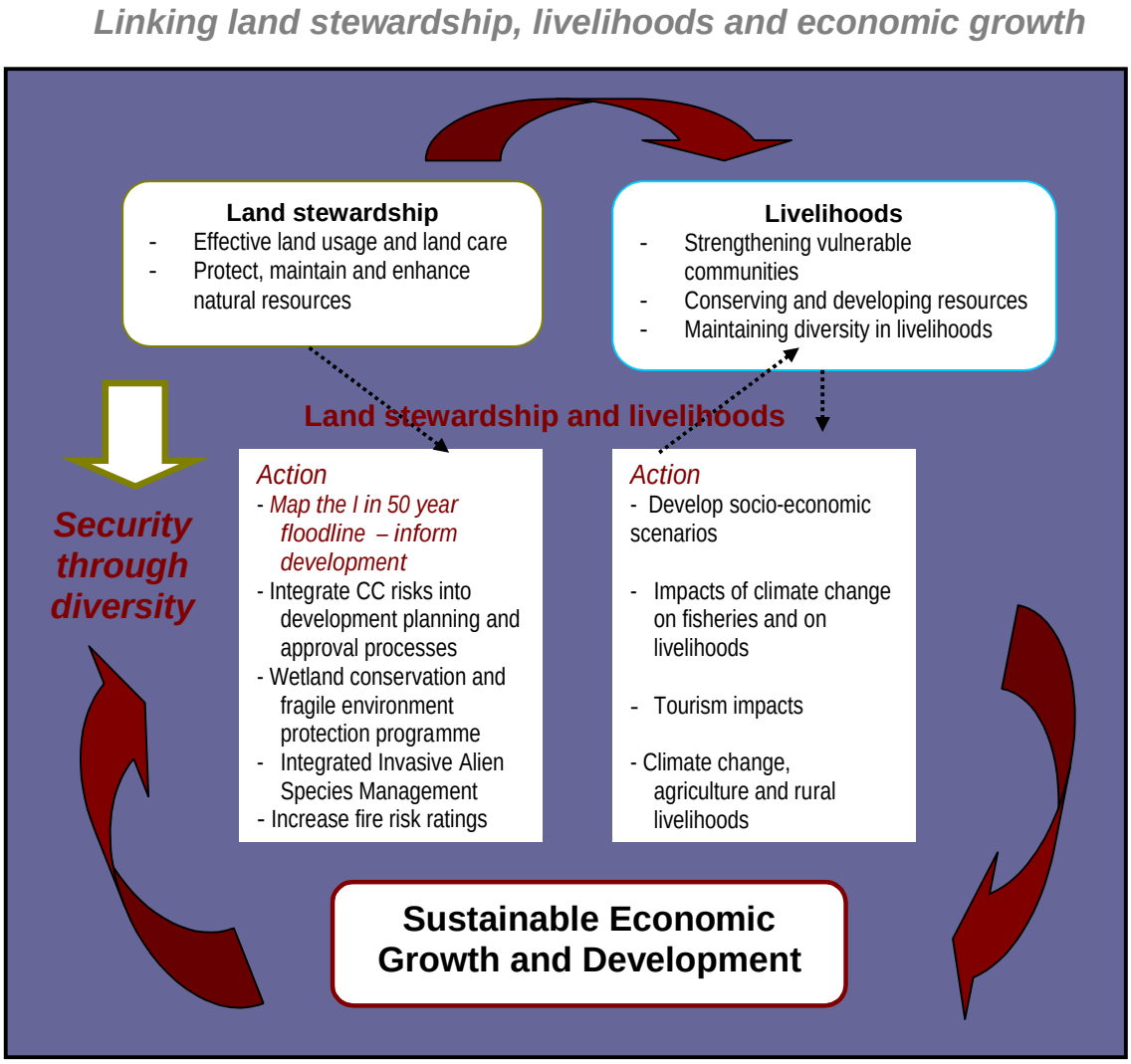
Land stewardship can be defined as *the practice of carefully managing land usage to ensure natural systems are maintained or enhanced for future generations*.

Carefully managing land-usage in the face of climate change implies five focal issues:

- Caring for the system as a whole through an understanding of the fundamental roles and values of natural systems; building up biological fertility in the soil; incorporating an understanding of the ecological cycles on the landscape (water, energy, nutrients) and how land-use practices can either benefit, be in harmony with, or negatively impact these cycles and other land-users, flora and fauna. *All the above – in the face of climate change impacts.*
- Resource conservation: maximising efficient use of resources and striving to reduce the one-time consumption of renewable and non-renewable resources; aiming for long-term optimisation versus short-term maximisation of production. *All the above – in the face of climate change impacts.*
- Maintaining, building and enhancing stability in the natural environment – maintaining and encouraging natural biological diversity and complexity; maintaining natural areas and functions on the land and in wetlands (wildlife habitat conservation). *All of the above – in the face of climate change impacts.*
- Cultural values and ethics: caring for the health of the land for future generations and long-term economic stability; enhancing the link between civilisation, urbanisation, the land-base and ecosystems that are vital to survival. *All the above – in the face of climate change impacts.*
- Integrating land use and resource planning into ***the built environment*** considering natural resource and ecosystem issues in all development planning and approval processes – *in the face of climate change impacts.*

Figure 1.12 demonstrates the links between land stewardship, livelihoods and economic growth, depicting the related action plan components.

Figure 19: Linking land stewardship, livelihoods and economic growth



Source: OneWorld Sustainable Investments 2007

Land Care and Resource Conservation

There are four key action items and focus areas in considering land care and resource conservation:

- **Wetland conservation, riverine and estuary integrity**
- **Integrated Invasive Alien Species (IAS) Programme**
- **Extension of protected areas**
- **Fire risk management and control.**

Climate Change and Wetland Conservation

Wetland rehabilitation and protection play a potentially essential role in adapting to and mitigating climate change.

The projected effects of climate change (including increasing mean temperatures, changes in precipitation, sea level rise, and increased frequency and intensity of some extreme climatic events) will impact wetlands, their dependent species and the ecosystem services they provide. A combination of more intense and more frequent drought events coupled with heavier precipitation events are projected in many areas. Persistent drought in many regions of the world is already seriously affecting the ecological character of wetlands. Climate change, along with other land use and land management activities, is projected to exacerbate such problems (van Dam, *et al* 2002).

It appears that climate change will have its most pronounced effect on wetlands through alterations in hydrological regimes: specifically, the nature and variability of the hydroperiod and the number and severity of extreme events. Overall, it is generally accepted that aspects of climate change, such as longer and more frequent droughts and increased incidence of fire will have negative effects on the carbon balance of wetlands (Gitay et al 2001).

It is predicted that perennial drainage available to Cape Town will decrease by 58%, given the projected scenario of a 20% decrease in precipitation from present levels by the second part of this century (de Wit & Stankiewicz 2006).

Reduced flow in rivers will further influence the health and functioning of wetlands and estuaries already degraded by agriculture to include livestock farming and other activities. With projected increases in temperature and decreases in precipitation, climate change will inevitably exacerbate the stress on water resources in the future (Midgley *et al* 2005). This creates the risk

that wetlands will be threatened by the abstraction of increasingly scarce water resources for competing economic uses.

Wetlands are host to highly specialised biodiversity. Some Western Cape wetlands have global significance because they provide habitat to migratory wading birds that breed in other parts of the world. High altitude marshes that host some highly endemic and isolated species (e.g. ghost frog) are particularly vulnerable to desiccation (Midgley *et al* 2005).

Adaptation to these threats will be informed by the individual characteristics of the vulnerable ecosystems and species. The overall adaptation options would be to minimise changes in hydrological regimes. A specific focus should be placed on maintaining and restoring wetland ecosystem services related to flood attenuation, streamflow regulation, water purification and water storage.

Suggested action custodian: Working for Wetlands

Action Plan

Action:	**Responsibility**
▪ Determine and implement the Ecological Reserve for key wetlands	DWAF
▪ Institute efficient demand-side management, especially in the agricultural sector	DA, DWAF
▪ Integration of land and water resource management in order to reduce non-climate stresses on wetlands	DWAF, DA, DEADP
▪ Assessment and expansion of the protected area system to accommodate valuable but threatened wetlands	Working for Wetlands, CAPE, CapeNature, DEADP, SANParks
▪ Assessment of climate change-induced threats to wetland-based livelihoods (e.g. harvesting of waterblommetjies and restios and fisheries) and development of strategies to mitigate and adapt to these impacts	DEAT/SANBI? (to be determined)
▪ Assessment of the actual vulnerability of wetlands and wetland species and functions to climate change and sea-level rise	DEAT/SANBI? (to be determined)
▪ High priority management actions, including rehabilitation, in valuable wetlands that are likely to be lost or degraded	CapeNature, DA, DWAF, Working for Wetlands
▪ Reduce nutrient loading in rivers and protect/augment riparian vegetation to offset eutrophication effects of higher water temperatures	DWAF, DA
▪ Secure and rehabilitate wetlands that have potential to play key flood attenuation roles. Rehabilitate river channels to improve their ability to withstand and attenuate extreme flow events	DWAF, Working for Wetlands, Working for Water, DA
▪ Re-evaluate design criteria of dams, levees and other infrastructure for flood protection	DWAF, municipalities

Programme cost: estimated at R5.3 per annum over 25 years

Options included from the matrix:

- Assess risk and infrastructure vulnerability – Map the 1:50 year floodline (Built Environment (BE4) / Water (W1).

- Map highly vulnerable areas (flood-lines etc.) and implement development bans in highly vulnerable zones (BE4).
- Fisheries (F2): Research and plan integration of climate risks into operation management procedures Cost: R1.3m pa, 5 years.
- Integrate climate risks into development planning [Built environment: BE1, BE2, BE3, L2, T1] Cost: R7.8m, 5 years.
- Research and monitor climate change impacts on fisheries (F1)
- Strengthen and focus socio-economic data on vulnerable communities; develop scenarios (L1).
- Research the efficiency of water use by the agricultural sector (W7).
- Increase water efficiency through pricing strategies and awareness (W6).
- Set up protected areas along gradients/corridors of altitude, rainfall, etc. (B2).
- Rehabilitate river banks (fight floods) (B3), stop erosion and loss of soil.
- Implement the ecological reserve (W8).
- Factor livelihood issues into all aspects of climate change planning (L2).
- Review Disaster management processes and integrate climate change into planning (DM1).

Invasive Alien Species (IAS) Management

What is the challenge?

An ***alien species*** is a species that has been introduced into an area outside of where it naturally occurs, either intentionally or accidentally. Many alien species are beneficial, such as crop plants, domestic animals, plantation trees and garden plants. However, a small proportion of alien species are able to spread unaided, invariably with detrimental effects. This classifies them as ***Invasive Alien Species*** (IAS). They become a threat because, when introduced into a new area, they thrive as they are no longer controlled by the natural predators and pathogens (diseases) with which they co-evolved in their natural environments. Furthermore, the indigenous species they interact with have not evolved any defences against the alien species. Avian influenza (bird flu) is an example of such an interaction; local domestic bird populations (e.g. chickens, ducks, turkeys) are infected and killed by the virus carried by wild birds who are unaffected by it. Although humans are not usually affected by avian flu, many cases of avian flu in humans have been reported since the 1997 outbreak. Most cases have resulted from contact with infected poultry or from surfaces that have been contaminated by secretions/excretions from infected birds.

Invasive alien species include ***invasive plants, animals and microbes*** and their impact on human welfare is disastrous. Economic losses due to IAS are estimated to amount to almost 5% of the world economy [global GDP] – equivalent to approximately US$1.4 trillion per year. This is about three times the Gross National Product (GNP) of all African countries. IAS generally continue to spread unless actively controlled. It is estimated that the area in Africa infested by invasive alien plants (trees and shrubs) will double within 15 years if left alone.[24]

IAS and Climate Change

Climate change is set to radically alter natural systems such as water resources and will also compound the existing trend of habitat destruction. Both of these circumstances stress indigenous species. IAS are far more likely to be able to take advantage of altered systems in an 'inter-species competition' exacerbated by climate change. Dr Guy Preston states: *"Invaders*

[24] Invasive alien species: A challenge to NEPAD, published by the National Botanical Institute and the Global Invasive Species Programme, 2004

have shown a propensity to 'take the gaps' that climate change may open up"[25]. He explains that existing examples provide a basis for arguing that it is obvious that climate change will exacerbate the problems of invasions, and will allow for intelligent estimates of what might happen. He further states that, "*There are of course uncertainties, and we do not understand the full dynamics of inter-species competition, but we can surely give sufficiently robust projections as to what the potential risk is with current invaders".*[26]

Invasive plant alien species encroach on necessary ecosystems such as fynbos, creating conditions conducive to veld fires and drawing heavily on already limited and threatened water resources (The area infested by alien trees and shrubs already uses around 7% of South African water supplies[27]). Furthermore, unpalatable alien grasses – set to increase due to climate change – are invading land, and some weeds have health impacts.

Several ***pests and diseases*** occur in the Western Cape, with resulting agricultural and human health impacts. An avian invader, the Indian house crow, is an example of an invasive species that has made its way to the Western Cape on board ships after having been introduced into Zanzibar in an attempt to keep the island free of rubbish. This species has a devastating effect on indigenous bird populations, threatens local wildlife and affects agricultural productivity (through stripping fruit trees). More seriously this species poses a threat to human health because these birds are a vector for pathogens that cause cholera, typhoid, dysentery, and salmonella poisoning. They also pollute already scarce water resources.

The fruit fly is one example of an IAS that impacts negatively on agriculture and which is extremely sensitive to climate change – particularly to increases in temperature. The Western Cape is a significant exporter of deciduous fruits and the import market is extremely sensitive to fruit flies.

What is the solution?
An Integrated Invasive Species Management Programme for the Western Cape Province that incorporates:

Prevention and preparedness
Processes that include prevention (for example quarantine, monitoring and surveillance, quality management) and preparedness (for example incursion planning, determination of responsibilities, funding, compensation and legislation, training and awareness, research and development).

Early detection and rapid response decision-making
Initial reporting, preliminary assessment and diagnosis followed by problem containment decisions based on determining the scope of the problem (impact assessment processes).

Implementation and monitoring and review
Operational implementation response processes of predetermined response strategies. Containment strategies are developed and implemented where eradication is not possible. Once containment / removal is achieved, ongoing surveillance continues to ensure freedom from the pest or disease.

[25] By email, 14 April 2007
[26] Ibid
[27] Ibid

Goals & objectives of the programme

- To conserve indigenous biodiversity of the Western Cape both within and beyond protected areas through reaching maintenance levels on existing infestations and prevention of major re-infestations.
- To contribute to the achievement of the provincial growth and development strategy.
- To foster and partner communities who value biodiversity and share in the benefits.
- To maximize funding opportunities from commercial operations and other stakeholders.
- To manage the protected areas so as to achieve sustainable development and promotion of ecotourism facilities within the protected areas.

Action

Consolidate existing programmes such as Working for Water (WfW) and extend the programme scope to include all invasive alien species across the province. Allocate the requisite budget to make up the shortfall in existing budgets (for example the CapeNature budget for clearing invasive aliens) and establish a clear vision and strategy for the prevention and early detection and response from prioritised provincial zones and catchment areas.

Suggested action custodian: CapeNature; and utilise existing infrastructure. This could mean expanding the Working for Water programme.

Action Plan

Action:	**Responsibility**
• Establish an Alien Species Management Working Group & Co-ordinator and establish a Programme Steering Committee (representative of relevant stakeholders, including community representation)	CapeNature as lead with DEA&DP, Department of Agriculture, Department of Health, DWAF (Project Steering Committee)
• Develop clear Terms of Reference and a clear vision and targets in priority areas	CapeNature
• Consolidate current programmes	CapeNature with PSC
• Develop provincial and regional strategic plans	CapeNature
• Employ dedicated Area and Project Managers	CapeNature
• Develop appropriate IAS policies	CapeNature with PSC
▪ Establish public private and community partnerships (for example, between Department of Agriculture and farmers (through the industry associations) on pest management programmes	CapeNature / PSC / Appropriate department and industry and community associations
• Establish monitoring platform	CapeNature with PSC
• Establish clear communication channels and channels for disseminating information	CapeNature; Provincial Climate Change Committee (PCCC) and DEA&DP communications
• Communication, Education and Awareness campaign	DEA&DP communications

Programme Development

- In the **short term,** consolidate existing programmes, identify priority regions and create capacity. Integrate the IAS management programme fully into the relevant departmental structures and line management as a core business priority.

- Develop 3-year business plans for invasive aliens in the **medium-term** and identify mechanisms to determine and source adequate long-term funding. In the **medium to long-term**, develop a strategic plan that is based on identified provincial priorities, such as land care management that improves natural resource management processes and sustainable livelihoods. Guide resource allocation through best practice planning and subsidisation procedures.

- The programme requires a partnership-based approach (communities, public and private sector) and a cross-sectoral focus in that it affects agriculture, water and health – ***ultimately with significant issues for livelihoods.*** Collaboration between different diagnostic agencies and between relevant state agencies and private companies, access to emergency funding and pest risk assessments are critical success factors to an integrated programme.

Cost Effective Analysis

The cost of eradicating alien species rises rapidly with the density of the infestations. This strengthens the argument for prevention, early detection and rapid response processes. The current spend on invasive species control in the Western Cape is approximately R103m per annum[28]. The Working for Water Programme under DWAF and administered by CapeNature has demonstrated successes, but the allocated budget and Terms of Reference do not allow it to have a province-wide scope and vision.

CapeNature is responsible for alien invasive control in the province. At this stage the organisation has an annual budget of R16 million (from DWAF) for invasive alien vegetation control in the **mountain catchment areas**, with additional budget allocations approved from 2007. According to CapeNature, R35 million is needed per annum (at 2004 prices) over a 25 year cycle to effectively control ***plant alien species alone***, resulting in a shortfall of R19 million per annum. Given a cost of R8.8 million for ***riparian zones***, this implies a cost of R15.2 million per annum for all other terrestrial zones.

Table 7 shows how clearing costs escalate relative to the density of the infestation, indicating the cost effectiveness of proactive management.

Table 7: Total costs of clearing for selected species (figures indicate clearing cost/ha)

Density	*Acacia*	*Eucalyptus*	*Hakea*	*Pinus*
Lightly invaded	R609.00 Initial + 1 Follow-up	R752.00 Initial + 1 Follow-up	R316.00 Initial	R567.00 Initial
Medium invaded	R2 596.00 Initial + 2-3 Follow-ups	R2 586.00 Initial + 2-3 Follow-ups	R1 779.00 Initial + 2-3 Follow-ups	R2 093.00 Initial + 1-3 Follow-ups
Densely invaded	R6 962.00 Initial + 3-4 Follow-ups	R5 869.00 Initial + 3-4 Follow-ups	R5 163.00 Initial + 3-4 Follow-ups	R4 906.00 Initial + 3-4 Follow-ups

Source: Marais *et al* 2004

Without taking into account impacts of climate change, and using existing density mappings and existing unit costs of clearing as collected by Working for Water, Blignaut *et al*

[28] This is made up of R15.7m through SANParks, R59m from EPWP (of which R20.7 goes to CapeNature), R11.2m from the DWAF trading account and additional budgets in CapeNature of R12m from DEAT and R5m from the Province.

(2007) estimated that **riparian clearing costs** for the four Western Cape water management areas (Gouritz, Breede, Berg and Olifants/Doorn Water Management Areas) amount to a total of R200 million – ***for these areas only*** – amounting to R8 million per year over a 25 year response cycle. A significant investment is required for the first seven to ten years to allow the province to take control of the problem whereafter costs should taper as the province moves into a maintenance phase.

However, in a comprehensive and integrated cost analysis (again not taking into account climate change effects) Dr Christo Marais (DWAF) calculated that the Western Cape requires R609 million per year for ten years, followed by R150 million per year for a further 15 years for riparian clearing costs. This needs to be offset against the positive impacts that bio-control is having on the spread of certain species and is exclusive of inflation as well as climate change impacts. Furthermore this budget does not focus on emerging species and invasive grasses or certain agricultural pests and diseases.

Pest alien species control

It is estimated – ***as one pest management example*** – that Sterile Insect Technique (SIT) treatment for fruit fly in the Western Cape will cost between R200 and R400 per hectare per year. Costs vary due to land distribution of the treatment zone and a rule of thumb is that the sparser the distribution the more expensive SIT treatment will be. Farmers in the Hex River area, for instance, currently pay around R200/ha for fruit fly control. For example: 2 hectares within a 10 hectare area where the 2 hectares are at opposite corners of the property will be closer to R400 per hectare per year. The whole of the Western Cape could use this as an effective fruit fly control measure. The fruit growing area in the Western Cape (citrus, pome and stone fruits, table and wine grapes) amounts to 117 575 hectares, implying a total annual cost of SIT of R35 million per annum using a cost of R300/hectare as a basis. Given the expected high private value of such a project, a public-private partnership is suggested. The ARC[29] suggested "*the logical extension of the current programme will be to create ever-larger contiguous areas under SIT with a view to later creating fruit fly-free zones in these areas. This is the longer-term goal of the SIT programme, for which substantial funding will be required."*

SIT is a capital-intensive programme and is an example of an aspect of an Integrated Invasive Management Programme where a public private partnership approach is appropriate.

An integrated budget that considers all invasive species cross-sectorally will need to be developed along with the Provincial Strategy and Integrated Management Programme. This can draw extensively on existing work and calculations, as discussed. The budget for dealing comprehensively with invasive species in the province must be considered in the cost of not doing anything as well as the impacts on sustainable development and poverty alleviation: estimates for the US indicate that alien plant invasions cost the US economy at least US$24 billion per annum. Selected studies within South Africa have shown that invasions have reduced the value of fynbos ecosystems by over US$11.75 billion and that the cost to clear invasive alien species in South Africa amounts to approximately US$1.2 billion[30].

Environmental, Social & Livelihoods Impact

The cost of the impacts of IAS on human health, livelihoods and essential basic services and resources such as water (including contamination) is already high, even before climate change factors are taken into consideration. *"IAS and climate change, together with habitat destruction are set to form a lethal cocktail for the basic things on which we depend for survival – our so-*

[29] See http://www.arc.agric.za/home.asp?pid=3783

[30] http://www.dwaf.gov.za/wfw/Research/ResourceEco.asp - taken from BW van Wilgen et al (2000): The Economic Consequences of Alien Plant Invasions: Examples of Impacts and Approaches to Sustainable Management in South Africa

called 'life-support systems'".[31] The programme presents an excellent opportunity for the Western Cape to adopt a multi-sectoral approach in demonstrating the importance of the prevention and removal of invasive alien species to society and in contributing to social and economic development.

Options included from the matrix:

Agriculture (A2; A3): Implement Integrated Pest Management control programme – IPM (e.g. control of fruit fly).
Water/Biodiversity (W5; B5): Remove invasive alien plants from riparian zones and catchment areas.

▪ Extension of Protected Areas

What is the challenge?

Various parts and aspects of the Western Cape's species, habitats, ecosystems and biodiversity are threatened by the effects of climate change. Changes in rainfall patterns and temperature as well as increased occurrence of fires pose a threat to the existence of many species and habitats. In order to preserve these areas from climate change effects, they need to be under conservation (declared protected areas). Midgley *et al* (in preparation) argue that 247 639 hectares still require protection, of which 6182 hectares fall within state-owned land. The remaining 241 457 hectares falls on private land and protection for these areas would be approached under general awareness programmes.

What is the solution?

Increasing protected areas requires a focus on public land and privately owned land. A targeted increase in protected areas on public land in the Western Cape is 6200ha by 2012. Furthermore, the Western Cape should introduce incentives to encourage private land conversion with a target of 120 000ha by 2010 and a further 120 000ha by 2020.

Suggested action custodian: Department of Environmental Affairs and Development Planning

Action plan

Action:	Responsibility
• Allocate required funds to convert identified public and private land at risk to protected areas	DEA&DP / Treasury
• And / alternatively engage private land owners in conservation activities through facilitative actions (Stewardship & LandCare programmes) accessing funds from the Adaptation Fund	DEA&DP (CAPE) / SANBI
• Identify research needed to be conducted to access Adaptation Funding (including identifying suitable land)	DEA&DP / SANBI
• Conduct research and apply for Adaptation Funding	CAPE / SANBI? (to be determined)

31 Ibid

• Convert 6200 ha public land by 2012 and place under management	CAPE
• Monitor private land conversion	CAPE

Cost Effectiveness Analysis

According to Martin (2003), the operational costs for 6200 hectares would be around $37/ha, compared to $18/ha reported by James *et al* (1999) and $71/ha reported by Frazee *et al* (2003). The latter specifically reported on the cost of protection in a biodiversity hotspot in the Western Cape, while James (1999) reported on the costs of global protection and Martin (2003) on general SANPARKs protection costs. For this reason the cost estimates of Frazee *et al* are used here. It is assumed that state land will be transferred at no additional land acquisition cost. However, as the average operational conservation costs per hectare declines rapidly with the size of the conservation area (Martin 2003), it will be worth estimating the additional costs of protection per hectare versus the additional benefits of doing so.

Given a cost of $71/hectare operational cost and no additional capital outlay, and a requirement to conserve an additional public 6200 hectares to adapt to climate change, the costs of protection is estimated at R3.2 million per annum (R1 = $7.3).

If required public and private land is converted to protected areas using this model, this would imply adaptation at a cost of R125 million per annum. Given that this land mainly comprises dry and wet mountain fynbos, the costs of acquisition would be priced at a weighted average of R270/hectare in 2003 costs (see Frazee *et al* 2003 and R1 = $7.3)), adjusted to R330/hectare at 2007 costs using a simple inflationary adjustment of 5% per annum (although property prices have in the last four years increased at a rate significantly in excess of the accepted inflation rate). Using these figures, the cost of acquisition is estimated at R80 million. If coastal, low land or forest and thickets are involved the costs will be higher. A more realistic alternative would be to engage private landowners in conservation activities through facilitative actions. This is also the focus of the Stewardship and Land Care programmes where private landowners receive some benefits for management of their land. The Adaptation Fund would be an appropriate vehicle to obtain support for such efforts.

Environmental, Social & Livelihoods Impact

The environmental effectiveness argument is clear and the programme fits strategically within a broader land care focus which aims to improve natural resource management practices and sustainable use and management of natural resources. The programme encourages collective action by communities (farmers for example) and thus can encourage communities to adopt sustainable management practices and improve their productivity, profitability and the conditions of the Western Cape both on and off farms.

Increasing protected areas that are currently under agriculture could reduce the employment opportunities available for farm labour. However, the cost is important environmentally and potential jobs could be created from protected land.

Options incuded from the matrix:

Extend protected areas (Biodiversity B2)

Fire risk management and control

What is the challenge?
Destructive wildfires have a high socio-economic impact (when they occur in urban and peri-urban areas, and when they destroy livelihoods), as well as a significant biodiversity impact (when they occur in natural areas, e.g. fynbos). From a social perspective, the impact is particularly on households living in informal settlements that are threatened or destroyed by such fires. Economically, the annual cost of destructive wildfires is high and the CSIR (2006) concluded that the annual economic cost of destructive wildfires in South Africa is estimated at R743 million per year. Of this, the bulk was due to losses in downstream timber processing (estimated at R252 million per year), livestock and grazing losses (estimated at R155 million per year) and losses associated with alien plant control (estimated at R100 million per year).

For the Western Cape's valuable biodiversity, the veldfire risk in fynbos is already high, although the CSIR report states that this is not extreme or catastrophic:

> *[The risk to] fynbos, which is well known for its veldfires, has been rated as high and not extreme. Here, in spite of events such as the fires on the Peninsula in January 2000, most fires occur in remote areas and even though large and intense, result in moderate levels of consequence. Even the January 2000 fires on the Cape Peninsula were not catastrophic.*

However, the most destructive and costly fires are those on urban fringes and in association with big weather events (Midgley, this study). During the November – April 2004 fire season, 1 200 fires were reported in the Western Cape to which Working on Fire responded at a cost of R8 million (Minutes of the IDMC's Veld And Forest Fires Working Group Meeting, 18 May 2005). Working on Fire is a service provider to the Fire Protection Associations (FPAs). During the 2005 season, R9.4 million was allocated to the Working on Fire programme in the Western Cape. These high costs are directly related to the high expense of fire fighting equipment. For instance, according to the Department of Water Affairs and Forestry, it costs close to R23 000/hour to keep a Working on Fire programme helicopter in the air. This is in addition to the annual "standing fee" of R1 million per helicopter (Anon 2006).

Wildfires and climate change
The Western Cape is already at high risk of wildfires. Changes in climatic events and related impacts conducive to veld fires will only compound this already high risk. Climate change-induced stress factors such as increased temperatures, drying and an increase in wind velocity will provide additional cause and will exacerbate the spread of wildfires.

What is the solution?
Raise all Western Cape municipalities' fire risk ratings one level, i.e. from moderate to high (or from high to extreme), and increase the budgets for Fire Protection Organisations accordingly.

Suggested action custodian: DWAF

Action Plan

Action:	Responsibility
▪ Identify key improvement and performance areas in Fire Protection Organisations and Services	DWAF / Cape / Disaster Management Unit and Local Authorities

▪ Introduce municipal level risk rating and damage cost reduction targets	DWAF / Office of the Premier
▪ Budget for improved capacity – resources and equipment and implement	DWAF / Disaster Management Unit / Treasury
▪ Budget for improved Working for Fire communication, education and awareness campaigns	DWAF / Treasury
▪ Introduce spot fines for human activity that can lead to fires (e.g. throwing lighted cigarette butts, making fires in prohibited areas)	DWAF / Office of the Premier (to be determined)
▪ Strengthen conservation guard control capacity and manpower	DWAF / CAPE? (to be determined)
▪ Implement communication and awareness campaign	DWAF communications department / Working for Fire

Cost Effective Analysis

When analysing *response costs*; according to Kruger *et al* (2004) (as quoted in CSIR 2006), the baseline cost of a Fire Protection Organisation (FPO) in an area with an extreme or high-risk rating is R375K per annum, compared to R130K in a moderate risk area. Climatic changes in the Western Cape are likely to increase the risk rating and thus also the costs of adapting to fires in the province (DEADP 2005). If fire risk ratings of all municipalities are adjusted one rating upwards and assuming a similar density of FPOs per hectare the additional costs for FPOs would amount to R7.5 million. The total cost of existing and new FPOs in the province would increase from R5.5 to R13 million for such a scenario. There is no concrete information available to further specify the impacts of climate change on fire risk rating in the Western Cape and this figure should be used as indicative only.

The *damage costs* of destructive veld fires are estimated at around R15 million per year for the Western Cape when a land value based approach is used, but can be as high as R30 million when figures are proportionally adjusted for anecdotal evidence supporting national estimates.

Environmental, Social & Livelihoods Impact
Improving the fire risk ratings is likely to have a significant impact on reducing the impact of fires on livelihoods where households lose their life possessions and people may be severely injured. The impact of fire on the fynbos is significant and should be considered in the context of the fynbos' value in terms of biodiversity and eco-tourism as well as in terms of the eco-system's competitive relationship with invasive alien species, given the latter's better adaptive capacity and the consequences for already scarce resources such as water (see notes under Invasive Alien Species Management).

Options included from the matrix:

- Disaster Management (DM1): Review DM processes and integrate climate change into planning.
- Biodiversity: Fire management (B1)

Climate Change and Development Planning – the Built Environment

Climate change presents impacts and risk that exacerbate existing pressures on the built environment. Infrastructure that is built on the floodline, for example, is at risk and extreme events already experienced in the province are at considerable cost – cost that can be avoided with informed decision-making and careful development planning.

The financial losses incurred in the southern Cape storms during the 2003-2006 period amounted to some ZAR 900 million and the table below demonstrates that infrastructure has been rebuilt with each storm event and has been replaced regularly only to be susceptible to the next weather event.

Event	R million
2003	212
2004 Eden district (indicative)	60
2005 Bredasdorp	5
2006 August	+650
Total	**+927**

Table 8 Approximate direct financial losses caused by storm events in the Southern Cape during the years 2003-2006 (source: A Holloway, Disaster Mitigation for Sustainable Livelihoods Programme, Dept of Environmental and Geographical Science, UCT, pers. comm.).

A number of development planning and approval processes exist within the private and the public sectors. Ultimately, the public sector (government) holds the key in that major planning decisions require government or government agency approval.

An aspect to take into account in development planning in the light of climate change is the relationship between sustainable communities and their location and public transport. A number of studies have shown that incorporating public transport into development planning encourages efficient land use patterns and provides more balanced transport options (Belzer D., Autler G., 2002). From the point of view of location of communities for sustainability, **location efficiency** is cited as saving both transport costs and achieving reduction of GHG emissions (at no explicit additional cost). Clearly there are also significant socio-economic benefits in communities being situated near work places and urban service centres and on efficient, cheap public transport lines. From a purely climate change perspective, the benefit will be to local air quality improvement and ultimately to national greenhouse gas emissions – ***through reducing the province's transport based carbon footprint.***

▪ Integrate climate risks into development planning and approval processes

What is the challenge?
Many planning decisions focus on shorter timescales and tend to neglect the longer-term perspective (OECD 2006). The OECD (2006) provides several suggestions on how to more effectively integrate climate change adaptation into development activities:

- Make climate information relevant and usable by highlighting the uncertainties of climate change, the costs, effectiveness of adaptation measures, the distributional aspects and the variability of climate change impacts on development projects.
- ***Integrate climate change into Integrated Development Planning processes and establish accountability to the Premier's office.***
- Require an insurance quote including ***a mandatory climate change risk assessment by the insurer*** (to include self insurance schemes).
- Develop screening tools to assess exposure of development activities to climate risks.
- Use appropriate 'entry points' for climate information such as land use planning, disaster management, infrastructure design, environmental assessment, investment planning and legislation.
- Shift emphasis to the implementation of existing environmental or development priorities and plans (e.g. water and energy conservation, flood control) rather then developing new climate change plans, and focus on removal of barriers to implementation.
- Co-ordination and sharing of good practices such as between Millenium Development Goals and bottom-up consideration of climate change impacts.

Several other options have been highlighted that focus on the link between climate risks and development planning:

- Integrate climate risk in development infrastructure: ***Cost: R1.3m pa, 5 years.*** Climate change poses a risk to development infrastructure that needs to be managed in a systematic way.
- Establish robust building standards that incorporate climate change and implement these. ***Cost: R1.3m pa, 5 years.***
- Integrate climate change into development planning and approval processes ***Cost: R1.3m pa, 5 years.***
- Map highly vulnerable areas; floodlines etc and implement development bans in highly vulnerable zones ***Cost: R1.3m pa, 5 years.***
- Factor livelihood issues into all aspects of climate change planning ***Cost: R1.3m pa, 5 years.*** Integrate climate change factors into integrated development planning (IDP). ***Cost: R1.3m pa, 5 years.*** The responsiveness of IDPs need to be tested for climatic changes. This would involve the development of a guideline to include climate change factors on smaller spatial levels (as well as strategic options) to adapt or mitigate to climate change, into integrated development planning.

Suggested programme custodian: Department of Environmental Affairs and Development Planning

Action Plan

Action:	Responsibility
Integrate Climate Change into IDPs: • Develop guidelines for integrating climate risks into IDP processes – manual • Identify 2-3 pilot municipalities to test these guidelines and run a pilot • Re-inform the guidelines and appoint a task team to support municipalities in the process of developing their IDPs with reference to climate change • Establish guidelines for IDP reviewers to assess adequate integration of climate risks into IDPs under review	DPLG with support from DEA&DP
Map the 1:50 year floodline and disseminate information to local authorities and developers as well as to EIA reviewers to ensure responsible development planning and decision making: • Populate municipal infrastructure database for study area (if not already done) • Apply 1:50 and 1:25 year floods zones to infrastructure displays (where available) • Record entities at risk + values of replacement (including lives and livelihoods where possible) • Ground-truth for possible failure of infrastructure – e.g. undersized culverts, inappropriately placed infrastructure.	DWAF, in conjunction with DEA&DP, DPLG and The Office of the Premier
Integrate climate risks into EIA processes • Formulate guidelines and a manual that facilitates project approvers to consider climate risks in their approval processes. • Establish accountability	DEA&DP
Research and plan integration of climate risks into Operation Management Procedures in fisheries • Climate change poses a risk to fishing stocks that are already depleted by exploitation and this needs to be managed in a systematic way.	MCM in consultation with DEA&DP

Cost Effective Analysis

- **Map the 1:50 year floodline: Assess risk and infrastructure vulnerability**

Human development on the 1:50 year floodline is risky and places human lives, private developments and public infrastructure at serious risk in the eventuality of a flood. Mapping the floodline will provide development decision-makers and investors as well as insurers (in government's case, state assets are self-insured with heavy financial risk) with information and a decision-making tool. It will also arm early warning systems and disaster management and recovery units with the means to identify high flood risk areas and to plan accordingly.

The province has experienced high costs of flooding and although this cannot be directly attributed to climate change, it does increase uncertainty of climatic variability as a driver of

these events. Integrated hydrological-climatological research is needed to inform planning for the floodlines in high-risk catchments (e.g. Groot Brak, Mosselbaai, Wilderness areas).

Cost: R1.3m per annum over 5 years - This cost (and other research actions in the Response Strategy and Action Plan) have been costed fairly generically. The costs estimated are based on research being conducted over five years at average research rates in the Western Cape.

Social, Environmental and Livelihood impacts

Communities that inhabit and function within the floodline are at risk in terms of lives and livelihoods. Planning for new development that takes the collated data into consideration will facilitate informed decision-making that reduces impacted communities' exposure and therefore risk. The information can also be effectively used to assess where adaptive capacity in already-exposed communities and infrastructure exists – and to strengthen where necessary.

Information may point to moving extremely vulnerable communities, which usually comes at a social and even a cultural cost to the community and an economic and political cost to government. Mitigation in both instances is through thorough communication, education and awareness-building within the communities concerned.

Options included from the matrix:

- BE4 Assess risk and infrastructure vulnerability – Map the 1:50 year floodline (Built Environment (BE4) / Water (W1)
- F2 Fisheries (F2): Research and plan integration of climate risks into operation management procedures Cost: R1.3m pa, 5 years
- Integrate climate risks into development planning Built environment: BE1, BE2, BE3, L2, T1] Cost: R7.8m, 5 years

Livelihoods

Livelihoods are impacted on by climate change and in turn have the ability to impact on economic growth and development. A decline in agricultural activity, for example, will in turn affect related jobs, which could mean a loss or reduction in rural livelihoods. An unfortunate outcome would be that the diversity in the economy is reduced which would place increased stress on urban development and resources.

Livelihoods require industry (primary and secondary) for sustenance – as well as natural resources and energy. Industries are equally dependent on these resources but perhaps have a greater capacity to adapt. A water-dependent beverage plant may, in the event of a sustained drought, decide to relocate its plant outside of the drought-affected area and it is unlikely that it would move back. Fisheries have a natural adaptive capacity as fish stock migrate to waters where nutrients are available or water is of a suitable temperature. A significant industry investor will most certainly evaluate resource availability in its location decision and consistent energy supply is certainly a factor. All of the examples described have potential livelihood impacts in addition to the impacts that will already be felt through reduced conditions in resource availability and quality. Understanding and planning for livelihood impacts and consequences in

the context of climate change requires further research and careful planning but, most of all, calls for an integrated approach and a clear focus on caring for land, developing and protecting resources and integrating climate risks into all development planning decisions.

The Livelihoods Programme includes the following actions:

- Strengthen and focus socio-economic data about vulnerable communities; develop scenarios
- Fisheries: Research and monitor climate change impacts on the industry – particularly fishing stocks
- Fisheries – Research the social impacts of climate change on communities and livelihoods
- Tourism: Research impacts of climate change on tourism demand and projected growth

Vulnerable Communities

What is the challenge?
The current and projected future vulnerability of communities across the Western Cape needs to be determined to guide allocation of resources to strengthen adaptive capacity where it is most needed. Socio-economic data of the resolution required for a scenario development exercise is not consistently available in the province and focused research should fill the gaps identified.

***Recommendation**: A critical need for the province is a more in-depth socio-economic analysis of the determinants of adaptive capacity in the Western Cape followed by an analysis of the **province's communities with the least adaptive capacity**. This will allow ranking of provincial communities according to levels of vulnerability, adaptive capacity and resilience.* [32]

The Department of Social Services is in the process of completing a Community Level Survey in the Province, which will yield relevant data and results by November 2007. This data will provide the basis for scenario development.

Suggested action
Research is needed to provide spatially refined socio-economic data and scenarios for the province and its various sub-regions, explicitly taking into account the impact of climate events. These scenarios need to be publicly available and regularly updated (at 5-yearly intervals) and will inform an efficiently targeted adaptation policy.

Cost: R1.3m over 5 years This cost (and other research options) was estimated generically based on research being conducted over five years at average research rates in the Western Cape.

[32] Municipal districts frequently include a number of communities with widely differing socio-economic status (for example Saldanha on the West Coast). This makes it difficult to identify vulnerable communities.

Options included from the matrix:

- Livelihoods (L1): Strengthen and focus socio-economic data about vulnerable communities; develop scenarios Cost: R1.3m, 5 years

Climate Change and Fisheries: Monitor fishing stocks

Overview of the fishing industry

The South African fishing industry is centred on the West Coast and the industry is characterised by competition for scarce resources and a significant degree of natural uncertainty – all of which is expected to be exacerbated by climate change. The industry has been through significant change in the period between 1998 and now – primarily through the fishing rights and allocation processes that have been revised and implemented and which have seen changes in the structure of the industry.

What is the challenge?

Fish stocks in the Western Cape waters have certainly depleted – more so in some species than others – largely due to exploitation. Climate change is likely to further exacerbate this situation and monitoring the impacts of climate change on stocks will in turn help inform the Operation Management Procedures (OMPs) and resultant Total Allowable Catch (TAC) calculations. There is currently a lack of figures regarding the impact of climate change on fishing stocks. This option is valued at the cost of weather monitoring as discussed in option 3.2.2.

It is generally accepted that the way climate affects marine life is complex and largely undocumented (IPCC 2001; Schjolden, 2004). It is difficult to predict impacts on fisheries in the Western Cape without an underlying better understanding of how marine systems work and how these will be impacted by climate variables. It has been noted that if a change in the passage or volume of the Agulhas current is set to occur, the impacts on fisheries in the province would be substantial (Kiker 1999). A more immediate impact is the reduction of freshwater run-off reaching Western Cape estuaries, a situation that may be aggravated by lower levels of precipitation (Kiker 1999). It is well-known that the fisheries productivity of estuaries (breeding grounds for many fish species as nursery grounds) correlated strongly with size and mouth conditions (Lamberth & Turpie 2003).

Cost: R1.2m pa over 7 years

Options included from the matrix:

- Fisheries: Research and monitor climate change impacts on the industry – particularly fishing stocks (F1)
- Research and plan Operation Management Procedures

Climate Change and Fisheries: Research social impacts on communities and livelihoods

What is the challenge?
The aforementioned restructuring of the fishing industry achieved through the right allocation processes aimed in part to redistribute the wealth in the industry. One key outcome is that the industry is significantly more geared to a high level of capitalisation, and consequently debt[33]. Climate change may aggravate the socio-economic impacts of changing fisheries stocks and yields, with the possible consequence of reduced capacity to realise the value of capital and increased over-capitalisation in the industry.

There is currently not enough information about communities and livelihoods dependent on fisheries in the province, although this dependence is considered to be significant in particular 'pockets' of the Western Cape.

Suggested action
Research is needed to provide understanding of the sensitivity of livelihoods and local economies dependent on fisheries to historic and projected climatic changes in order to better inform an adequate response strategy.

Cost: R1.3m pa over 5 years This cost (and other research options) was estimated generically based on research being conducted over five years at average research rates in the Western Cape.

Options included from the matrix
Fisheries (F3): Research the social impacts of climate change on communities and livelihoods

Climate Change and Tourism: Research impacts of climate change on tourism demand and projected growth

What is the challenge?

The linkages between climate change and tourism are complex and uncertain (see discussion in text box for an example). The length of the season may be affected by changing temperatures and precipitation, a rise in sea-level could lead to a loss of resources such as bathing beaches, a reduction in stream-flow run-off could limit water sports and recreational fisheries and changing ecosystems could impact niche-market activities such as bird-watching. Warmer and drier conditions can have implications such as droughts and fires, water shortages and poor air quality - all impacting on tourism (WTO 2003).

[33] Rights allocations are relatively long-term, ranging between 10 and 15 years, depending on the sector. Applicants have been forced into significant investments to cater for this. Furthermore, the industry has seen significant investment (partly through State coffers) in BEE deals in the industry (Dave Japp, May 2007 personal comms)

Suggested action

DEA&DP (2005) recommended that the sensitivity of tourist behaviour to climatic changes (temperature, precipitation), extreme events, induced physical changes such as beach degradation and induced biological changes such as a loss or migration of species is researched in more detail before more informed estimates on potential socio-economic vulnerabilities and damage costs can be made. This research needs to be conducted in the context of the tourism sector in the Western Cape and the growth expectations of that sector.

Box 4: Carbon caps and tourism to the Western Cape

Carbon caps[34] and tourism to the Western Cape

The European Union is presently considering capping greenhouse gas emissions in the aviation industry, implying that Europeans would pay more for their air travel in future. Given that around two-thirds of the Western Cape's tourism arrivals originate from Europe, and that these tourists are responsible for R8.5 billion in spending per annum, it may be an important issue for the province's plans to attract 1.7 million overseas tourists spending over R20 billion in the province by 2010.

The price elasticity of demand for air travel differs between business and leisure and also between shorter and longer trips. Based on the results of a comprehensive meta-analysis performed in 2001, median estimates vary considerably between -0.265 to -1.520. The study lends support to lower price elasticities for longer haul flights and especially for longer haul business trips. Median estimates for business is -0.73 and for leisure -1.52. For long haul international business the median price elasticity is -0.265 and for long haul international leisure -0.993. The variation in the latter, however, is high.

The Western Cape is mainly a holiday destination, with business accounting for no more then 25% of overseas arrivals from Europe. Given that all other factors affecting travel demand to the Western Cape are equal, and following the median estimates as explained, a 1% increase in costs would lead to an estimated 0.27% decrease in business travel and an estimated decrease of 0.99% in leisure travel. All other variables being equal, a weighted average would mean that a 1% increase in international long haul flights to the Western Cape would lead to a 0.81% decrease in demand. Assuming that a decrease in arrivals would lead to an equal decrease in expenditure, a 1% increase in price may therefore lead to a loss of R68 million per annum to the provincial economy.

As travel demand is primarily driven by many other factors such as income and the variables affecting destination choice, these estimates should be interpreted with caution before general statements are made. Carbon pricing will only affect costs and not other variables in a direct way. It is also not clear yet to what extent international air travel prices will rise or be absorbed in the cost structure of international airlines.

Information in this write-up was based on the following sources:

Gillen, D. 2001. Air Travel Demand Elasticities: Concepts, Issues and Measurement. Report for the Department of Finance Canada.

Grant Thornton Fessel Keinsten/Wesgro, 2002. Western Cape Tourism and Investment Trends. Wesgro/Western Cape Tourism Board.

Grant Thornton Fessel Keinsten/Wesgro, 2000. Western Cape Tourism and Investment Trends. Wesgro/Western Cape Tourism Board.

[34] Carbon caps are restrictions on carbon dioxide (CO_2) emissions.

Programme coordinator & custodian: Department of Environmental Affairs and Development Planning through the PCCC

Action Plan

Action:	Responsibility
Develop socio-economic scenarios using social services data (as stated) • Research socio-economic impacts on communities and livelihoods affected in the fishing industry • Research the implications of growing populations on water and energy as scarce resources	DEA&DP
Research the implications of climate change on fishing stocks	MCM, coordinated by DEA&DP
Research impacts of climate change on tourism demand and projected growth	National DEAT, co-funded by WC Department of Economic Development and Tourism

Cost: R1.3m per annum over 5 years
These costs (and other research options) are estimated generically based on research being conducted over five years at average research rates in the Western Cape.

Options included from the matrix:
Tourism: Research impacts of climate change on tourism demand and projected growth

Mitigation Response Strategy and Action Plan: Reducing the footprint of the Western Cape

Mitigation Response Strategy and Action Plan Overview

Outcomes and objectives

The mitigation-based strategic response and action plan for the Western Cape is developed against the key strategic outcome of reducing the province's carbon footprint. This will be achieved through inputs, activities and outputs based on the following identified objectives:

- Coordinating the Western Cape's input into climate change mitigation strategies at national, regional and local levels
- Pursuing economic opportunities from the Province's renewable energy and other local cleaner alternate energy resources and proactively developing these
- Establishing the province as a low greenhouse gas emitter by continuing to encourage the efficient use of energy by government, industry and the community
- Maintaining the Western Cape's targeted status as a low greenhouse gas emitter through the promotion of sustainable land management
- Supporting research into the impacts of climate change in the Western Cape and the development of innovative responses to climate change that can be replicated elsewhere
- Working with and involving the community in responding to climate change.

Guiding principles

The Western Cape government will lead by example in the identified drive to reduce the provincial carbon footprint and to establish the province as a low emitter. It will, however, build on co-operative partnerships with industry, within the different tiers of government and with the community. The government will also facilitate the provision of key information and policy guidance through co-ordinating targeted research, monitoring activities and through the development of informed policy on mitigation where necessary.

In terms of a time-frame for implementing a renewable energy-based energy supply for the Western Cape, the issue of 'peak oil' should also be considered. With the possibility of remaining available oil supplies dwindling, it is likely that cheap affordable transport fuels may not be available for much longer. This will make it more costly and more difficult to implement renewable energy programmes that may be dependent on transport for infrastructure. This possibility suggests that time-frames for the implementation of renewable energy sources should be treated with more urgency. For more information on peak oil refer to www.peakoilrsa.com and the Association for the Study of Peak Oil and Gas – South Africa at www.aspo.org.za .

Box 5: The Kyoto Protocol: Extension of carbon emission caps

The Kyoto Protocol: Extension of carbon emission caps post 2012

The first commitment period of the Kyoto Protocol ends in 2012. This period was characterised by the commitment to reduction in GHG emissions by the industrialised countries that are signatories to the Protocol. With the end of the first commitment period, it is considered highly likely that developing countries that are signatories will also be required to commit to targets for capping

(limiting) their GHG emissions. South Africa's status as a signatory to the Protocol, and as an industrialising country with relatively high emissions, as well as technological ability, makes it a likely candidate for such a commitment/GHG emissions target. This likelihood increases the importance of having a strategy in place to limit the Western Cape's carbon emissions.

Mitigation Response Options

Energy and Climate Change Response Options

The Western Cape Energy and Climate Change Programme incorporates four suggested projects:

1. Air Quality Monitoring Project
2. Household Fuel Replacement Project
3. Public Transport on Cleaner Fuels Project
4. Energy-efficiency and Renewable Energy Project

The Status Quo review effectively highlights the key climate change impacts on the Western Cape Province in terms of energy. The Risk and Vulnerability Assessment conducted as part of developing this Climate Change Response Strategy and Action Plan emphasises the provincial's energy consumption as being a significant contributor to national, regional and local greenhouse gas emissions. The source of this pollutant energy usage includes energy imported from the Mpumalanga coalfields as well as locally combusted coal, paraffin and wood fuels, the latter of which contribute directly to poor local air quality with resultant health impacts for residents.

The key actions identified involve inputs, activities and outputs that are designed to ***enhance energy efficiency*** initiatives, targets and demand side management-based incentives and to maximise the usage of the province's relatively unexploited, yet rich, ***renewable energy resources***. An envisaged secondary outcome is the commercialisation of some of the significant human capital and renewable energy technology innovations that the province is home to - thus maximising the economic benefits available.

Furthermore, a fortuitous additional outcome of a more climate change-sensitive energy economy in the Western Cape is that the economic risks of energy utilisation in the future will be minimised in proportion to the level of investment in more localised and cleaner energy infrastructure.

Funding mitigation responses and the Clean Development Mechanism (CDM)

Under the Kyoto Protocol, developing countries may contribute to reduction of greenhouse gases by implementing clean energy production processes and engaging in the CDM process.

Under the Kyoto Protocol, developed countries are to reduce their greenhouse gas emissions by an average of 5% below their 1990 levels in the period between 2008-2012 (In some cases this is equivalent to a 15% reduction in their expected levels without caps). Mitigation measures for industrialized countries ('Annex 1' countries) include the possibility

of meeting reduction targets by **buying carbon credits** (by subsidising carbon reduction measures in developing countries, through the Clean Development Mechanism (CDM) Executive Board).

In order to quality for CDM funding, various requirements need to be met, for example inventories of greenhouse gas emissions and carbon sinks.

The Clean Development Mechanism (CDM) is a source of financing for mitigation options being considered in the Western Cape. The CDM is a flexible economic mechanism created under the auspices of the Kyoto Protocol to bring a revenue stream from industrialised countries into emission reduction projects in the developing world. Emission reduction projects such as certain clean technologies (for example, waste management options) and renewable energy projects (for example, wind farm developments) can generate Certified Emission Reduction (CERs) units, which can be traded in the international market - thus bringing a source of financing to the development of the project.

Whilst Cape Town is home to the first registered CERs in South Africa, relatively few projects are registered in the Western Cape. This is because the Western Cape is neither home to heavy industry nor to significant levels of electricity generation (a significant contributor to South Africa's greenhouse gases). Mitigation options that could qualify for the CDM in the Western Cape include programmatic CDM for Solar Water Heating project development, energy efficient housing, agriculture methane capture and biomass opportunities, and localised electricity generation projects such as wind farm developments.

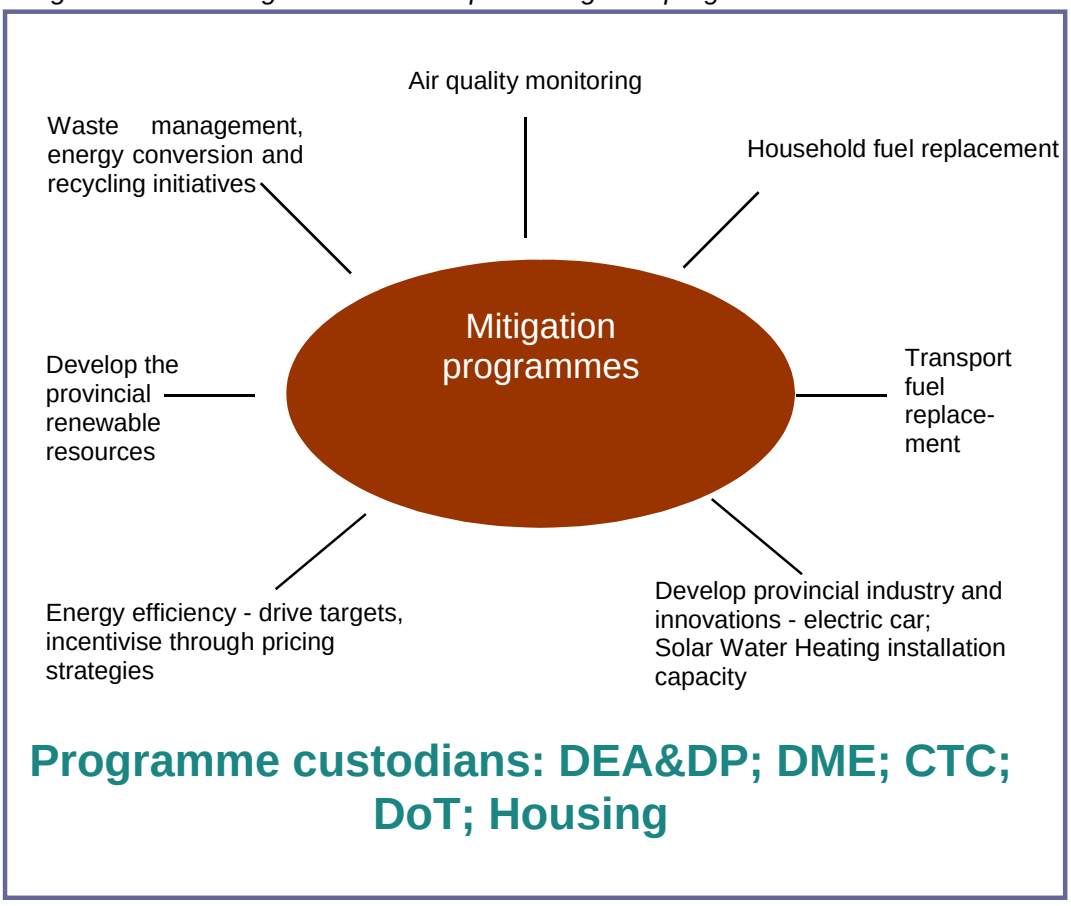
For a full consideration of the current CDM portfolio in South Africa, please refer to the *CDM Supplementary Report* of the *Western Cape Climate Change Response Strategy and Action Plan.* This report includes the complete CDM portfolio in South Africa.

Key outcome # 4

Reduce our carbon footprint

Energy and Climate Change

Figure 20: Reducing our carbon footprint: Mitigation programmes



Source: OneWorld Sustainable Investments 2007

Air Quality Monitoring

What is the challenge?

The link between energy, air quality and climate change

Carbon dioxide in the province arises from electricity use first, followed by petrol and diesel consumption. Transport and local energy combustion (such as woodfuels, paraffin and coal) impact on local and indoor air quality conditions. Climatic changes cause meteorological changes, which in turn have an impact on the frequency and intensity of pollution episodes - with significant implications for human health. The City of Cape Town already experiences air pollution episodes, but for rural areas the measurement of ozone is important. There is no specific urgent need to measure greenhouse gases on a more spatially refined level, although better measurements of methane and carbon dioxide closer to land surfaces would certainly reduce uncertainties.

Existing air quality monitoring in the province is under-capacitated, resulting in inconsistent and inadequate data and information for robust early warning systems. The international rule of thumb is to allocate one air quality monitoring station per 250 000 people[35] Cape Town has 10 stations in place at present to monitor for approximately three million people. The Province has recently purchased three stations at a capital investment of R1.7 million and is currently considering criteria for determining their location. This needs to be increased with two more stations. An estimated 1.75 million people live in rural areas, which would equate to a requirement of at least seven air quality monitoring stations to cover the rest of the province complemented by the hiring and training of three to four staff members.
Capacity building in monitoring takes on two forms: namely (a) human capital and (b) technology/equipment. At present the City is operating at one person for every three stations (one person per two stations is optimal). Human capital is a concern in the City of Cape Town. Thus any resources directed towards the city would be spent on hiring and training staff to operate and maintain the stations currently in place. Outside of the Cape Metro area, both the technology and the human capital need to be addressed.

What is the solution?

Establish two to four more air quality-monitoring stations in Cape Town and seven new stations in the rest of the province (these numbers include the 3 stations purchased but not installed). Train three to four new staff members. Budget capital, human resource and operational costs as stipulated above.

Suggested action custodian: Department of Environmental Affairs and Development Planning and Local Authorities

Action Plan

Action:	Responsibility
▪ Verify locations	DEA&DP with Local authorities
▪ Allocate budget for stations and for education and awareness and response / early warning systems	Local authorities / Treasury
▪ Establish monitoring human resource capacity	Local authorities

[35] Ravenscroft, personal communication

and train	
▪ Establish clear channels for disseminating monitored data (with reference to the AQ Management Act	PCCC / AQ Committee
▪ Establish early warning mechanism and system with the Provincial Disaster Management Unit structures (local authorities) and the Department of Health	PDMU / Local authorities / Dept Health
▪ Establish communication channels with the Office of the Premier – for example to communicate high pollution events and to inform the public	PCCC / Office of the Premier
▪ Establish guidelines for the public during high pollution events that aim to reduce / minimise the impact	AQ Management committee
▪ Educate and communicate	Local authorities? (to be determined)

Cost effectiveness analysis

According to the City of Cape Town's Air Quality Monitoring Laboratory, an additional R3.26 million in capital costs and R1.065 million in operational costs is needed for air quality monitoring (Table 1.8). Additional capital costs for Vehicle Emissions Monitoring Stations would amount to R680K. Total capital cost funding required is therefore R3.94 million and operational costs R1.065 million (excluding provision for capital but including staff, travel, maintenance and consumables). This budget assumes that the additional stations are run by the Centralised Accredited Test Laboratory & Calibration facility currently running the ten stations for the City of Cape Town. If this is not the case, significant additional costs would accrue in setting up the infrastructure to run the stations.

Table1.8: Additional Air Quality Monitoring Costs

		Air Quality Monitoring Station Budget				
Type	Parameters	Cost – Capital*	Cost Operational **	No. of stations	Total Capital	Total Operational
		R	R p/a		R	R
Urban	Nox, SO2, PM10, O3, Met	650000	200000	2	1300000	400000
Rural	O3, Met	280000	95000	7	1960000	665000
				***Total R	3260000	1065000

Notes: * Includes Shelter, Datalogger, Aircon, inlet system, gas reticulation, etc.
** Includes staff costs, travel, maintenance, consumables, etc.

Source: Ravenscroft, G. Head: Air Quality Monitoring Laboratory, City of Cape Town.

The greatest value lies in providing early warning to communities, particularly in the event of high-pollution episodes. Effective communications and awareness campaigns on these could have the impact of reducing the intensity of the pollution episode (for example, people burn less fuel for specified periods; Capetonians reduce vehicle usage). The Status Quo Review identified the need for improving the availability of background information and data for policy-makers. Strengthening the provincial air quality monitoring and data analysis and dissemination systems is a critical response that assists in addressing this identified need.

Environmental, social and livelihoods impact

Strengthening the air quality monitoring capacity is not going to have direct positive impacts per se and certainly will not induce negative impacts. The effective use of the data and related analysis will provide positive impacts (albeit secondary): to the environment in terms

of reducing severe pollution events (if effectively managed); socially in terms of human health if early warning and response improves because of the improved information and economically if Cape Town and environs can reduce the brown haze that may, if it worsens, negatively impact on tourism, for example.

Options included from the matrix:

- Strengthen and extend air quality monitoring network and capacity for early warning (Energy/Air Quality:E3)

Household Fuel Replacement

What is the challenge?

In 2005, nearly 9 000 homes were destroyed in the fires that occurred in informal settlement across the City and 1 327 fires were reported in informal settlements between 1 January and 26 December 2005 (City of Cape Town 2006). Climatic changes in the Western Cape are likely to increase the risk of fire days (DEA&DP 2005; Hewitson, this study). One of the contributors to fires in informal settlements is the use of paraffin.

Of the 12 726 000 households in South Africa in 2005, 2 145 000 relied on paraffin as the energy source for cooking. In the Western Cape, 105 000 households still rely on paraffin as an energy source for cooking (SSA 2006). Although many households are electrified, many use paraffin for cooking, water heating and space heating (Winkler *et al* 2005).

Table 1.9: Paraffin use in the Western Cape (households thousands)

	RSA	Western Cape (WC)	WC/RSA (%)
Cooking	2145	105	4.90%
Heating	1579	219	13.87%
Lighting	482	27	5.60%

Paraffin is often ingested by children or leads to accidental burning and premature deaths. One estimate puts the external costs (not counting deaths) of paraffin in South Africa at almost R8/litre (PDC/Science Consultancy Enterprises, 2003). As paraffin is zero VAT rated in South Africa, the subsidy amounts to over R441 million pa (738 million litres * R4.27/litre * 14%) (www.sapia.org.za). The Western Cape used an estimated 111 million litres (or 15% of country-wide use) of paraffin in 2006, valued at R473 million and implying a subsidy of R66 million. Using the assumptions stated above, the social cost of paraffin use (excluding deaths) in the Western Cape is estimated at R888 million/annum.

What is the solution?

The development of an integrated fuel replacement and ceiling installation programme targeted at vulnerable communities and low cost housing areas. A programme of this nature requires political will (leadership, action, policy and incentives / subsidies), education, awareness and public private partnerships. The links between climatic changes and the increased use of paraffin and hence risks of paraffin-induced fires in low-income human settlements needs to be highlighted. Communities must be fully informed of the risks of choosing paraffin and wood as opposed to other alternatives. However, the fuels predominantly selected are significantly cheaper than cleaner alternatives such as gel-fuel

and LPG. A policy-driven incentive programme has to be put in place as a driver for a fuel-replacement programme.

Education campaigns are needed to increase awareness about (a) energy savings in low-income settlements and (b) the displacement of perverse paraffin subsidies.

The problem also needs to be considered holistically: although financially still not viable (DEA&DP 2007), the installation of ceilings in low-income houses decreases the need for space heating (Winkler et al. 2005). Space heating is responsible for 35% of paraffin consumption in low-income households (Simmonds and Mammon 1996). Housing building standards should be improved to include insulation through ceilings, thus reducing the requirement for space heating. The experience and monitored data from the Kuyasa CDM Project confirm the benefits of enhanced thermal comfort levels (and associated reduction in external energy needs) due to the implementation of ceilings. A switch from paraffin to other energy sources for cooking will account for another 45% reduction in paraffin use.

The introduction of a province-wide plan to introduce LPG, gel fuel or other forms of energy in mass housing development to replace paraffin is suggested as an action point in the integrated energy strategy (DEA&DP 2007). It can be expected that the replacement of paraffin with more affordable fuel sources will lead to health improvement and improved safety in informal settlements.

Suggested action custodian: Department of Housing

Action plan

Action:	**Responsibility**
▪ Extend the existing subsidy for ceilings in new houses to retro-fitting of existing houses	Housing
▪ Establish subsidies for alternate fuels (gelfuel / LPG) and related equipment (Stoves, heaters)	Housing / Treasury
▪ Monitor the impacts of revised safety standards as developed by the paraffin industry on fire incidents and losses induced by fires	DEA&DP / DMU / Health
▪ Establish distribution networks in the high density areas (peri-urban and rural)	Housing
▪ Establish a communication education and awareness programme (communications strategy)	PCCC and Housing communications department with Office of the Premier? (to be determined); Disaster Management Unit (under the fire brigade unit)
▪ Establish monitoring platform	DEA&DP

Cost Effectiveness Analysis

The case for installing and retrofitting ceilings is confirmed in the Kuyasa CDM Project. A comprehensive analysis exercise is required to fully answer this question. This needs to examine the costs of the perverse paraffin subsidisation currently in place against the costs of producing and distributing alternate fuels such as LPG and ethanol gel fuel. This can also not just be considered in terms of fuel costs, but also with consideration to the related appliances and equipment. An LPG cooker can cost up to ten times more than a paraffin stove. However, an LPG cooker (as one example) is safer, with related (multiplied) savings in terms of destructive shack fires and health costs. Truran (2004) reports between 60,000 and 80,000 paraffin ingestions by children per year. Paraffin smoke and fumes also contribute to respiratory disease - a major health problem in poor households.

Environmental, social and livelihoods impacts
It will be important that monitoring information obtained from strengthened air quality management systems (see above) is used to focus on pollution levels on the Cape Flats, as air pollution can be particularly intense at this level below the inversion. Informal settlements are prone to shack fires and pollution due to fuel sources used within confined areas (indoor air pollution). A subsidised fuel programme would therefore be advantageous to social well-being, livelihoods and health as well as to energy consumption induced emissions. As such, it has multiple potential social, environmental and economic benefits. The paraffin industry has however done considerable work on improving health and safety standards with the intention of substantially reducing fire risks and hazards. Should these measures prove effective, continued paraffin usage would become more of an emissions issue.

Options included from the matrix:

- Instigate a subsidised programme to displace paraffin and wood fuel burning (Energy/Air E4)

Public Transport on Cleaner Fuels

What is the challenge?
Private passenger transport dominates the transport sector demand and accounts for 75% of energy use in the transport sector, public transport for 20% and freight and rail for 4% (DEADP 2007).

On a typical day, 69% of total trips are private and 31% public. During morning peak hours this split is 48% public and 52% private (CCT 2006). A split closer to 60:40 is set as a target for 2020. The passenger rail system, however, conveys some 602 000 passengers per day, accounting for 53% of public passenger trips (CCT 2006). Mini-bus taxis account for 29% and buses 18% of public passenger trips. The growth in the taxi industry in the province has been significant as the railway system cannot cope with growth in transport demand – either because of access or issues of over-crowding. Safety and security are also factors.

Public transport in the City of Cape Town operates on considerable subsidies. Metrorail subsidies are estimated at R250 million for 2004/5. The Golden Arrow Bus Service received a subsidy of R360million in the 2004/5 financial year, up from R130 million in 1997/98. Commuter rail fares are determined by the national government, bus fares by national and provincial government and minibus-taxi fares by the operator (CCT 2006). The White Paper

on National Transport Policy is aimed at achieving greater efficiencies in the delivery of subsidized public transport services.

The switch from private to public transport is directly promoted in the draft public transportation plan of the City of Cape Town (City of Cape Town 2006) and in the George Mobility Strategy - which aims to transform the transport sector in the George area with a view to introducing an accessible user-friendly public transport service – and supported in the integrated energy strategy. The focus will be on:

- additional investments in train sets
- upgrading of stations
- corridor planning (e.g. bus lanes)
- cycle and pedestrian ways in the CBD
- possibility of a rail link between the airport and the CBD
- a new public transport system for George linked to training and skills development facilities with the stated objective of making economic development opportunities accessible to all.

The transport sector and climate change

The transport sector consumes 34% of the Western Cape's energy and contributes 22% to carbon emissions (DEADP 2007). Economic growth in the province will see an increase in demand for transport services and the growth in the new passenger vehicle market nationally is significant and indicates the increase in vehicles on our roads. Planned economic development in the George area is potentially very high with an envisaged R100 billion spend between now and 2010 on transport, a new convention centre, housing and other facilities and infrastructure. This development will see an increase in carbon emissions as well as degradation in local air quality unless mitigated.

What is the solution?

Given the high energy usage of transport in the Western Cape, it is suggested that the planned strategic *Review and development of a fare structure and subsidy policy in the light of the City's transport and development agenda* (CCT 2006) include inputs on more sustainable fuels for bus and taxi transport. The George Mobility Strategy (currently in design and planning phase) should also consider running a significant percentage of public transport vehicles on cleaner fuels and the fact that this will be a new transport service provides an excellent opportunity for achieving stated targets. The cost of enhanced services needs to include the rising costs of energy and the pollution costs of using buses and taxis for public transport. This will lend support to the vision for public transport in the City, namely a *safe, effective, efficient, equitable and affordable public transport system that supports sustainable, social and economic development in an environmentally responsible manner.*

The second prong to the climate change response based solution is to introduce a biofuel-blending programme in the Western Cape. This should be aligned with the Draft National Biofuel Strategy that is currently considering public comment[36]. The Western Cape could consider a higher fuel blend (the draft national strategy proposes 1%) and could consider biodiesel and bio-ethanol. The province can, however, only afford to concentrate the programme on the demand side. Producing biofuel from known feedstock crops is water intensive – a resource that is already extremely limited in the Western Cape – and biofuel production value chains across the world are under the spotlight for not meeting the net energy balance requirement – i.e. inputting more energy through the value chain than is achieved in output.

[36] As submitted by 10 March 2007 to the DME

As reviewed under Development Planning, the issue of location efficiency is relevant when planning public transport and communities.

Box 6: Electric cars – an innovation for the Western Cape?

Electric cars – an innovation for the Western Cape?

Commercial opportunity also exists within the transport sector although it is likely to fall primarily in the private domain. Optimal Energy (see www.optimalenergy.co.za) have, with initial funding from the South African Innovation Fund, developed the concept for a locally produced electric vehicle that will run on rechargeable batteries. The objective is to commercialise this innovation and to establish a local assembly and production line that could be franchised for market penetration throughout South Africa. The province should see a prototype before 2007 is over, with a further two envisaged for 2008 before the company goes into production in 2010.

The vehicle combines state-of-the-art design with innovative technology and aims to come into the market at a level competitive with known brands such as Toyota and Volkswagen in the R130-150,000 price range. The vehicle will run on Chinese-developed and produced lithium batteries with a range of between 200 and 400km depending on the size.

A pilot is envisaged within the public sector, with government testing the first 50 vehicles in its local fleet here in the Western Cape. A successful pilot could result in government establishing a clear target for replacing, say, 10-15% of its fleet with locally produced electric cars by 2014.

Suggested action custodian: Department of Transport

Action Plan

Action:	Responsibility
▪ Research subsidy structure ▪ Research alternate fuels – viability – CNG or LPG or biofuels	Department of Transport; CTC and in context of the George Mobility Strategy (Eden Municipality
▪ Incentivise Taxi industry / Golden Arrow to use CNG / LPG / Biofuels	DoT / Treasury
▪ Allocate budget	DoT / Treasury
▪ Convert 30% of provincial vehicles to CNG/LPG /Biofuels by 2010 ▪ Integrate programme into provincial initiatives such as the George Mobility Strategy and the Worldcup 2010 Transport strategy	DoT DoT / Ninham Shand / Actios
▪ Communication education and awareness	DoT communications department / PCCC
▪ Monitor impacts	DoT / PCCC

Cost Effectiveness Analysis

The phasing in of a transport-based replacement fuels programme requires research and a full feasibility study. The research and feasibility study phase would consider what the stated targets should be for a fuel blend programme (with consideration to where the biofuel supply

would be imported from) and for conversion of public vehicles to cleaner fuels, such as CNG. Such analysis must consider social and environmental impacts as well as the costs of having to displace emissions should South Africa receive post-2012 emission reduction targets, or in the event of voluntary targets being adopted. The health costs (in terms of air quality) also need to be factored in as well as tourism impacts. The research cost is estimated at R500k per annum over a three-year period. Existing initiatives, such as the George Mobility Strategy, can integrate a feasibility assessment now by introducing, say, 30% of new buses running on CNG / LPG.

Environmental, Social and Livelihoods Impact
Using cleaner fuels in the transport sector could have indirect impacts on health through reduced emissions. The costs of public transport, however, impact significantly on livelihoods – the poor spend a more significant proportion of their income on transport so it is important that a fuel switch is subsidised. Cleaner fuels will also assist in negating the envisaged growth in transport-induced greenhouse gas emissions and preferably in reducing the overall carbon footprint of the Western Cape.

References
Burer M. J. *et al, Location Efficiency as the Missing Piece of the Energy Puzzle: How Smart Growth Can Unlock Trillion Dollar Consumer Cost Savings*. Research paper Presented 2004.
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Options included from the matrix:

- Reduce diesel and petrol consumption through creation of a Public Transport system running on cleaner fuels (Transport TR2)

Energy-efficiency and Renewable Energy

What is the challenge?
The provincial integrated energy strategy (DEA&DP 2007) highlights energy efficiency improvements in the sectors using the most energy: industry (46%), transport (34%), the residential sector (9%) and commerce & government (4%). According to fuel type, the highest usage of energy is petrol (34%), followed by electricity (31%) and diesel (20%) (Figure 21). Although the Western Cape's greenhouse gas per capita is far lower than the national average, more efficient use of energy may decrease this even further.

Several technological and behavioural options for energy savings are proposed in the strategy, but the use of the pricing mechanism to achieve such savings needs to be explored in more detail. Several issues related to energy pricing have been highlighted in the strategy (DEADP 2007):

- New coal generation capacity would already place upward pressure on electricity prices
- The sale of carbon credits on energy efficiency and renewable energy projects (e.g. solar water heating)
- Fiscal reforms can help to remove market barriers and finance clean energy initiatives.

According to Eskom, a 171MW savings from the energy efficiency demand-side management programme was achieved in 2006 (

Table 9). The energy efficiency component is 120.04 MW. This is 0.36% of the 2006 peak demand on the integrated Eskom system and 0.30% of power station net maximum national capacity.

Figure 21: Western Cape Energy Use Patterns. Source: DEADP (2007)

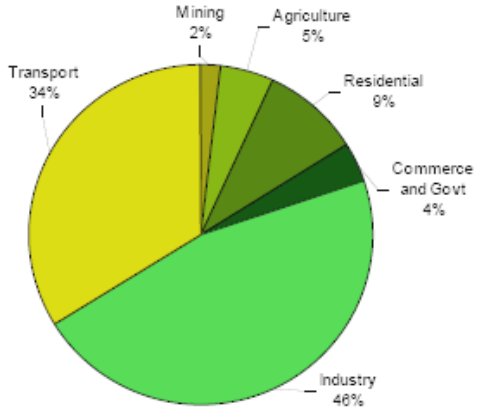


Chart 1:
Western Cape Energy Consumption by Sector

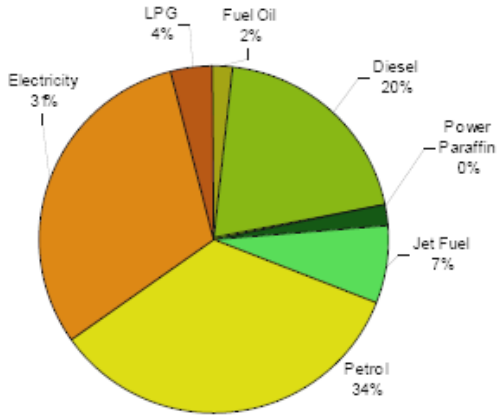


Chart 2:
Western Cape Energy Consumption by Fuel Type

The Western Cape seeks to improve energy efficiency compared to a business-as-usual scenario: 15% by 2014 and 20% by 2020 (DEADP). This compares to 12% on a national level (DME 2005). The importance of pricing within the context of the current and future electricity market needs to feed into the further planning of demand-side management strategies in the Province.

Table 9: Demand side management in Eskom, 2006

Sector	Description	Target MW	Actual MW
Residential	Efficient lighting initiatives and street lighting initiatives Hot water load control	81,0	91,9
Commerce	Building lighting retrofits Heating ventilation and air conditioning optimisation	14,0	22,9
Industry and mining	Use of variable speed drives, compressor efficiency and plant lighting retrofits	57,0	56,5
Total		152,00	171,3

Source: Eskom (2006)

What is the solution?

Achievement of DEA&DP's energy efficiency target requires support from a number of activities. These include policy and incentive structures, capacity building to support industries that develop and market energy efficient technologies (such as the Solar Water Heater industry) and regulatory mechanisms such as by-laws that ensure energy efficient developments. The National Energy Regulator South Africa (NERSA) is currently

considering consulting proposals to develop a feed-in tariff structure and the DME has completed a Tradable Renewable Energy Certificate Study to strengthen the regulatory, institutional and trading frameworks to support renewable energy development in the country. Given these developments and that DEA&DP is concurrently concluding its Integrated Energy Strategy, the options considered here are considered to be part of that strategy but with added support in terms of promotion, education and awareness programmes in the climate change context.

Suggested action custodian: DEA&DP (with reference to National DME)

Action Plan

Action:	Responsibility
• Integrate with WC Integrated Energy Strategy Targets	DEA&DP / DME
• Research and develop an appropriate pricing strategies	DEA&DP / Treasury
• Establish a capacity building and support programme for the EE and RE supply industries – for example the installation capacity of Solar Water Heaters	DEA&DP
• Finalise the proposed CTC by-law on SWH	CT City / DEA&DP
• Commercialise the SWH industry with government support	Economic Development and Tourism
• Establish a fund for financing domestic sector SWH installations and capital expenditure	DEA&DP – in partnership with Banks and the Insurance Industry
• Implement the Solar 500 programme and ensure effective monitoring of results	DEA&DP / CEF
• Communicate energy savings potential to domestic and commercial consumers	DEA&DP communications department
• Establish energy efficient standards for the housing development industry	Department of Housing; Local Authorities; DEA&DP
• Establish a clear communications, education and awareness campaign aimed at behaviour change in consumer patterns	PCCC; DEA&DP communications

Cost effectiveness analysis

Achieving energy efficiency targets in the Western Cape has a direct impact on our energy consumption and therefore on greenhouse gas emissions – and hence on the size of our carbon footprint. Achieving energy efficiency targets also has an economic impact in that the less energy we use, the less we pay – particularly where electricity is imported from 1800km away with transmission losses of between 8%–20%. Energy efficiency measures further help enhance the province's energy security - which is currently precarious. These measures should therefore reduce the cost of investment in new energy generation capacity for the province.

Developing new generation capacity from the rich provincial renewable and alternate fuel resources should make up the balance of the province's energy requirements. A provincial reserve – obtained from both energy efficiency savings and establishing local, clean feedstock-based generation capacity – needs to be established so that the economic and livelihood costs of power outages can be avoided.

Environmental, Social and Livelihoods Impacts

Energy supply is a basic service - and it is difficult to contemplate introducing energy efficiency measures into households that have only recently acquired electricity. This issue needs to be factored carefully into the design of related communication, education and awareness campaigns centring on energy efficiency. On the other hand, the construction of energy efficient houses through the implementation of appropriate building standards (such as ceiling insulation and incorporation of solar water heaters) will reduce the monthly household running costs – of particular significance to the poor – thus helping to increase disposable income.

Development of infrastructure can include building standards that make structures more able to deal with climate changes such as changes in temperature (or increased flooding). If these standards are optional, there are often higher costs. If standards are mandatory, it will be necessary to ensure that there are low-cost options for climate-sensitive building standards to cover all infrastructure. Informal housing is a good example of where cheap insulation could help households keep cool in hotter summers and warm in winter. At the same time this activity reduces emissions by requiring less winter space heating.

Insofar as pricing strategies are concerned, it is important that the poor are protected through differentiated pricing. Although there is already a free basic electricity allocation, it is important that the poor are not penalised due to a relatively higher portion of their income being spent on fuel.

Options included from the matrix:

- Achieve energy-efficiency and renewable energy targets through pricing strategies and awareness (Energy)

Waste Management and Climate Change

What is the challenge?

Effective waste disposal is problematic in the Western Cape, leading to initiatives dealing with reclassification of waste streams and resultant economic cost alterations. The majority of South Africa's Municipal Solid Waste (MSW) sites are not compliant with legislated standards, with significant social and health impacts. Many members of poor communities, and particularly children, sustain themselves through picking off dumpsites; with health impacts arising from dealing in organic waste – particularly, for example, where animal waste from abattoirs mingles with household and industry waste on sites that are accessible to communities. As cities and communities expand, the situation intensifies and the problem becomes a bigger and costlier one to solve.

There are a number of waste streams that require consideration – with differing calorific values. The latter are important when considering energy conversion that is economically viable. High silica value waste streams, for example, have low calorific value and could be land-filled instead. These are waste streams that typically come from poorer areas, such as a Khayelitsha waste stream; as opposed to a CBD waste stream that has a much higher calorific value. Table 10 shows waste streams, waste stream content and calorific values.

Table 10: Waste streams, waste stream content and calorific values

Examples of Waste streams	Waste stream content	Calorific value (high / low)
CBD	Food, cardboard, paper	High
City Suburbs	Biomass type, organic,	High
Khayelitsha	Silica based	Low
Rural / agricultural waste	Livestock waste (e.g. manure from poultry, pigs), straw, grass (mostly baled and utilised – high value and already effectively disposed of), food,	High – generally well tapped into already
Sewage sludge	Human waste	High

It is evident that integrated waste management solutions require prioritisation of problematic disposal processes and sites and a consideration of waste classification and related disposal costs (for example medical waste, as a category, carries a disposal cost of around R 1000 / ton, whereas municipal waste has a disposal cost of between R150 and R250/ton). The higher calorific value waste matter, if of significant volumes, can be effectively disposed of through conversion to an energy stream, whereas landfill options and recycling should be considered for lower value waste streams. Technology development, capacity building and job creation opportunities exist in all of these options but require an integrated solution in order for them to be harnessed.

What is the solution?

Integrated waste management strategies can create jobs, minimise environmental and health impacts of poor waste management and at the same time, allow the province to harness energy (methane capture) thus providing a mitigating response to climate change at the same time as enhancing provincial energy security with a localised, decentralised energy supply.

A number of ***waste management technologies*** are in use internationally and some of these are being developed locally at significantly lower cost in implementation than imported counterparts. Methane capture from landfill sites is a tried and tested technology, creating an energy resource that can be fed into the national grid, or used on site. Anaerobic digesters are effective where feedstock is consistent and combines, for example, livestock waste (manure), abattoir waste (blood and intestinal) and organic municipal waste (food), also providing an energy resource from methane capture.

A comprehensive opportunity assessment and 'as is' analysis of all Western Cape municipal waste sites and general waste management / disposal processes is required as a starting point in developing an integrated waste management strategy for the province. This is a research based action item, with results being possible within 1 year to 18 months. Identifying priority sites and actions should be a key outcome, at which point related policies, processes and technologies may be identified and / or cemented. A further government action item opportunity lies in Research and Development funding. There are technologies under development in the Western Cape that require testing for example.

Economic costs also require careful consideration. For example changes to classification of waste streams or alterations to legislation (for example legislation that bans the practice of dumping abattoir waste with municipal waste) have significant related costs which can completely alter the economics of – for example - energy conversion disposal technologies.

Currently the cost of disposal of the abattoir waste stream is lower than the costs of converting this stream to energy. However, once the anticipated legislated changes come into effect, the animal waste would fall into the medical waste category with significantly higher disposal costs. At this point, methane capture and energy conversion becomes a viable option. An example of the effect of reclassification may be seen in a Western Cape industry player: A paper processing company produces a waste stream that is potentially to be reclassified as toxic. Their disposal costs would at that point increase almost ten fold, making energy conversion as a disposal mechanism an attractive option. This same organisation has been badly hit by the power outages experienced in the Western Cape, providing an added incentive to pursuing this opportunity. The technology that could be deployed in this example is a fluidised bed that would effectively replace the electrode boiler, at the same time providing an on-site fuel source that would reduce the fuel consumption in the coal fired operation.

Other technologies deployed and being developed in the province include plasma, close-coupled gasification (and combinations of both) and anaerobic digesters (used for methane capture using abattoir and organic waste matter). A further potential opportunity lies in a process for converting old rubber tires into useful liquid fuels – an invention that received much attention during the 70s oil crisis.

Underpinning an effective solution is the issue of waste sorting processes, which ideally should begin at a household level. This will necessitate policy and possible regulations for how households separate and dispose of their waste. An alternative to regulation is incentives – for example through reduced rates and taxes or even community level incentives.

An integrated waste management solution for the Western Cape will need to address a number of levels in the waste management value chain and should incorporate recycling:

POLICY	Household and industry waste management policy; MSW policy
PROCESS	Waste sorting/ collection, classification, disposal processes
TECHNOLOGY	Methane capture, on site technologies for industry, recycling – ***R&D***
OUTPUT	Increased energy supply / reduced grid demand

Not only does integrated waste management provide a mechanism for reducing our provincial carbon footprint – it also provides a means for strengthening adaptive capacity and resilience through improved health conditions and economic empowerment opportunities.

Suggested action custodian: Local Government – MSW management, with PCCC coordination

Action Plan

Action	Responsibility
Opportunity assessment and analysis of all waste streams and provincial MSW sites and practices – including recycling opportunities and an analysis of job creation potential	Local Government and housing and PCCC / DEA&DP
Investigation of R&D opportunities and allocation of R&D budget	Department of Economic Development; DEA&DP; Treasury
Assessment of policy, possible incentives, appropriate processes to achieve integrated waste management	Department of local government; DEA&DP
Development of a clear waste management solution and action plan for implementation	DEA&DP; Department of local government

Cost effective analysis
At the time of publication of this report, detailed information regarding costing of related technologies and their application in South Africa were not yet available.

Part 2

Western Cape Climate Change Analysis – What is the problem?

Part 2: Western Cape Climate Change Analysis – What is the problem?

What is climate change?

Global Climate Change

Climate change is associated with past observable changes and future projections for various climatic indicators, such as temperature, precipitation and wind velocity. Scientists tracking these changes globally have found sufficient evidence of change in climatic indicators to say with certainty that climate change is occurring (IPCC Fourth Assessment Report, 2007[37]). The most obvious change observed has been in overall average global temperature, which has been rising over the last hundred years, with a particularly noticeable rise since the 1950s. However, there is also evidence from a multiplicity of other facets such as heat waves, or extreme events. The world is now warmer than it has been at any time in the last thousand years and greenhouse gas concentrations are higher than they have been in 650 000 years. The latest IPCC assessment report[38] presents a broad and extensive range of evidence showing that global change is detectable in many aspects of the climate system, and concludes that global warming is 'unequivocal'. The Fourth Assessment Report of the IPCC (Working Group 1)[39] published in February 2007 included the following statements:

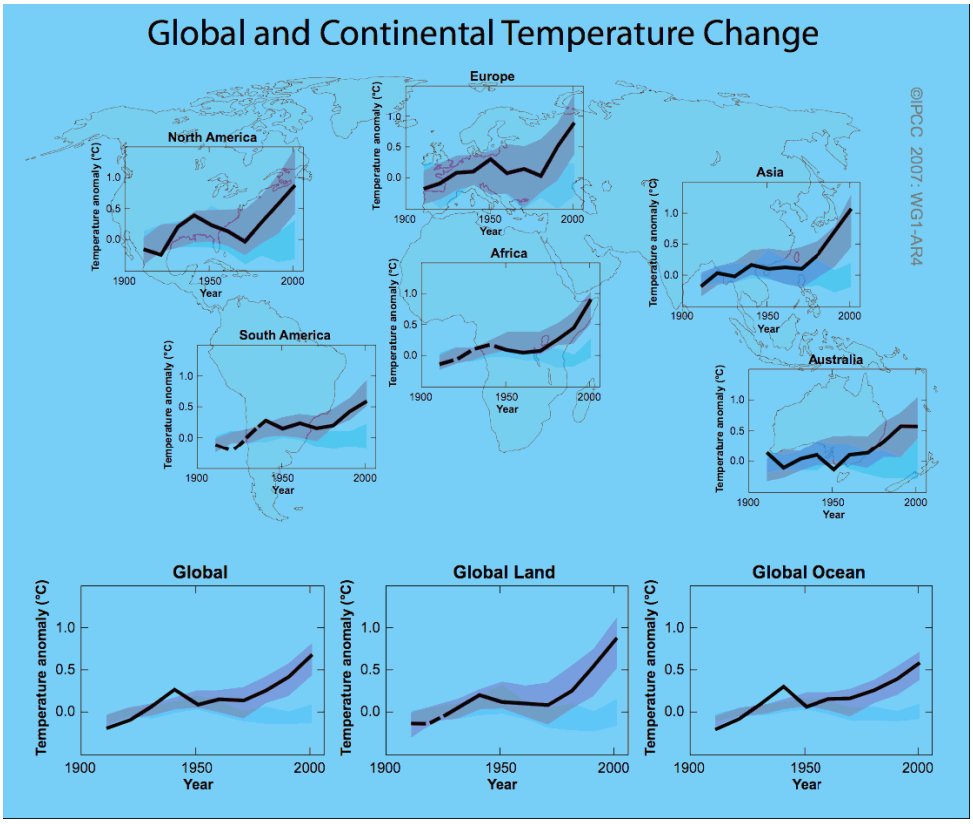
- There is a greater than 90% chance that human greenhouse gas emissions are affecting the climate.
- Between 1900 and 2005, drying has been observed in the Sahel, the Mediterranean, southern Africa, and parts of southern Asia.
- More intense and longer droughts have been observed over wider areas since the 1970s, particularly in the tropics and subtropics.
- Droughts have been linked to changes in sea surface temperatures.
- The best estimate for globally average surface air warming by 2100 is between 1.8 °C and 4.0 °C (likely range is 1.1°C to 6.4 °C)
- Carbon dioxide (CO_2) in the atmosphere is projected to reach 550-800 ppm (parts per million) by 2100 as compared with 180-300 ppm over the last 650,000 years. [Based on the most recent IPCC reports and related presentations and inputs from Dr G Midgley]

Figure 22: Comparison of observed continental- and global-scale changes in surface

[37] IPCC Fourth Assessment Report, Working Group 1: The Science of Climate Change, 2007.
[38] IPCC report CC SPM2feb07.pdf
[39] IPCC Fourth Assessment Report, Working Group 1: The Science of Climate Change, 2007

temperature with results simulated by climate models using natural and anthropogenic forcings.

Decadal averages of observations are shown for the period 1906–2005 (black line) plotted against the centre of the decade and relative to the corresponding average for 1901–1950. Lines are dashed where spatial coverage is less than 50%. Blue shaded bands show the 5–95% range for 19 simulations from 5 climate models using only the natural forcings due to solar activity and volcanoes. Red shaded bands show the 5–95% range for 58 simulations from 14 climate models using both natural and anthropogenic forcings. {FAQ 9.2, Figure 1} Source: IPCC 2007.



Source: IPCC, 2007]

These and many other changes are the first manifestations of global change brought about mainly by the increasing concentrations in the atmosphere of greenhouse gases (GHGs) such as carbon dioxide (CO_2) and methane, which are produced by human activities (The Status Quo Report, 2005; IPCCC Fourth Assessment Report WG1, 2007[40]). The increased concentrations enhance the natural greenhouse effect, and have precipitated various changes in global climate, which are reflected locally, as changes in the average regional climate, and also in changes in the frequency, persistence, or intensity of extreme weather events such as droughts and flooding (Status Quo Report, 2005; IPCC 2007). It has now been acknowledged and confirmed by members of the global community that continued anthropogenic (human induced) global climate change poses a 'serious global threat' (Sir Nicholas Stern *et al* 2006). Developing countries are the most sensitive to these changes, with vulnerable populations and growth and development severely threatened.

[40] IPCC Working Group 1 Fourth Assessment Report, Climate Change 2007: The Physical Science Basis: Summary for Policymakers, 2007, page 2.

Projected changes/trends

Climate change is looked at firstly in terms of changes or trends observed in recorded historical data, and secondly in terms of projected trends for the future. Table 11 from the IPCC report (IPCC, 2007) summarises some of the more apparent projected trends.

Table 11: Recent trends, assessment of human influence on the trend, and projections for extreme weather events for which there is an observed late 20th century trend.

Phenomenon[41] and direction of trend	**Likelihood that trend occurred in late 20th century (typically post 1960)**	**Likelihood of a human contribution to observed trend[42]**	**Likelihood of future trends based on projections for 21st century using SRES scenarios**
Warmer and fewer cold days and nights over most land areas	Very likely[43]	Likely[44]	Virtually certain[d]
Warmer and more frequent hot days and nights over most land areas	Very likely[45]	Likely (nights[d)]	Virtually certain[d]
Warmer spells/heat waves. Frequency increases over most land areas	Likely	More likely than not[46]	Very likely
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	Likely	More likely than not[f]	Very likely
Areas affected by droughts increases	Likely in many regions since 1970s	More likely than not[f]	Likely
Intense tropical cyclone activity increases	Likely in some regions since 1970	More likely than not[f]	Likely
Increased incidence of extreme high sea level (excludes tsunamis) [47]	Likely	More likely than not[f48]	Likely[49]

[Source: IPCC WGI Fourth Assessment Report; {Table SPM-2.Tables 3.7, 3.8, 9.4, Sections 3.8, 5.5, 9.7, 11.2-11.9} February 2007 (IPCC Working Group 1)

It is important to note that while climate change presents a serious threat to developing countries, it also presents new business opportunities. Developed countries such as the United Kingdom and some countries of the European Union have undertaken to reduce their greenhouse gas emissions, partly by supporting low-carbon developments in developing countries. This is evidenced through carbon trading schemes and offset programmes, using mechanisms that stand to benefit developing countries such as the Clean Development Mechanism (CDM).

What climate change is not - The hole in the ozone layer: an unrelated issue

[41] See table 3.7 in the original report for further details regarding definitions.
[42] [See Tables TS-4, Box TS3.4 and Table 9.4 in the original report]
[43] Decreased frequency of cold days and nights (coldest 10%).
[44] Warming of the most extreme days and nights each year.
[45] Increased frequency of hot days and nights (hottest 10%).
[46] Magnitude of anthropogenic contributions not assessed. Attribution for these phenomena based on expert judgement rather than formal attribution studies.
[47] Magnitude of anthropogenic contributions not assessed. Attribution for these phenomena based on expert judgement rather than formal attribution studies.
[48] Changes in observed extreme high sea level closely follow the changes in average sea level (…). It is very likely that anthropogenic activity contributed to a rise in average sea level. (…)
[49] In all scenarios, the projected global average sea level at 2100 is higher than in the reference period (…). The effect of changes in regional weather systems on sea level extremes has not been assessed.

Climate change should not be confused with the formation of the hole in the ozone layer. Ozone is a gas that exists in the Earth's atmosphere and protects the Earth from the dangerous ultra-violet (UV) rays of the Sun that cause sunburn damage. In the 1980s, scientists discovered very low levels of atmospheric ozone over the Antarctic. It was discovered that ozone levels were being depleted because of excessive amounts of organic compounds called chlorofluorocarbons (CFCs) in the atmosphere, produced by humans. CFCs were used in large amounts in aerosol sprays as well as in the gases that fuel fridges, air-conditioners and many other applications. The world was responsive to this issue and CFCs were banned by the Montreal Protocol in 1987. Ozone levels are expected to recover by the middle of this century, indicating that regulation and policy can result in a change in human behaviour on a global scale.

Our position in the global climate change regime

Regional climate change responses of South Africa and the Western Cape to a global issue

South Africa has acknowledged that: "*Global climate change is probably the greatest environmental challenge facing the world this century*."[50] The national strategy highlights the need to support sustainable development and recognizes the **overall vulnerability** of the country to climate change impacts.

Furthermore, South Africa is a signatory to the Kyoto Protocol (as a non-Annex I country) and as such has **certain obligations** to fulfil that, although at this stage do not include an obligation to reduce greenhouse gas emissions, do require periodic reporting on the national status of greenhouse gas emissions and carbon sinks. A further obligation is to formulate and implement national and regional (where appropriate) programmes to mitigate climate change and to facilitate adaptation to climate change. Developing countries need to balance economic growth with environmental protection (i.e. sustainable development) while expanding their economies and focussing on poverty eradication. The Western Cape has obligations in terms of the national compliance based issues, which require recognition in a regional response strategy and action plan.

Reducing greenhouse gas emissions obligations: The Kyoto Protocol is an amendment to the UNFCCC that provides developed nations that have signed the agreement with targets for reducing emissions of greenhouse gases. Countries categorised as developing countries, including South Africa, do not currently have to meet reductions targets (until 2012 at least) as, according to the principle of 'common but differentiated responsibilities', developed countries assume the leading role in the reduction of greenhouse gas emissions. They also contribute to the slowing down of climate change by formulating and implementing policies and measures aimed at reducing emissions. The UNFCCC is in fact more a convention on economy and development than a convention on environment.

In practice, this means that under the Kyoto Protocol (at present) developing countries have no restrictions (caps) on greenhouse gas emissions.

The discussions as to whether non-annex 1 countries who are Kyoto Protocol signatories will have emission reduction obligations after the first 2008 to 2012 commitment period of the Kyoto Protocol are ongoing, with the possibility that obligations will be incurred. The Western Cape is a relatively low direct emitter in the national context but it is a significant energy user (primarily fossil fuel based) and imports the bulk of its supply from the coalfields of Mpumalanga with

[50] A National Climate Change Response Strategy for South Africa, September 2004, Department of Environment and Tourism, p iii.

consequent transmission efficiency losses. The agriculture sector is also an emitter and a significant contributor to regional gross geographic product and the province is home to high pollutant industry.

Given South Africa's status as an energy intensive economy, the development of a **sustainable energy programme** for the country is critical and any regional response strategy and action plan must take cognisance of this. The Western Cape has already demonstrated its vulnerability in the energy sector. The province's insufficient level of energy security coupled with its abundance of renewable and other energy resources such as natural gas, points to the feasibility of developing a regional sustainable energy programme, which can on the one hand deal with existing energy vulnerability and on the other, address mitigation responses to climate change in the region, with a positive national contribution.

Nationally, the **vulnerable industries** are identified as the mining and energy sectors - both vital industries of the national economy. Vulnerable industries in the Western Cape, however, are primary sectors such as agriculture and fisheries. This, as well as biophysical evidence, points to the need for a robust regional (Western Cape) climate change response strategy and action plan.

There are **economic benefits** associated with global climate change that accrue to developing countries. The Kyoto Protocol provides for a flexible economic mechanism to facilitate the global reduction of greenhouse gas emissions: the Clean Development Mechanism (CDM). Accessing the CDM requires a national response in that national government-approved principles and processes are required to be in place before a developing country may participate in this mechanism. The Department of Mineral Affairs and Energy (DME) is the registered Designated National Authority as required by the UNFCCC and the steering committee is chaired jointly by the DME, DEAT and DTI.

To date, the Western Cape has seen a low level of participation in the CDM, although the province is home to the first project to register Certified Emission Reductions (CERs) in the country, through the Kuyaso project. This is however a relatively small project and needs replication to have the required impact.

Recommendation

The National Strategy on climate change provides guiding principles and requires regions and respondents to climate change to develop strategic direction and identify actions in response to climate change that meet peculiar and particular needs to that region. The Western Cape should identify its most vulnerable points (identified in DEA&DP, 2005) and develop a framework for risk assessment in each in order to inform the development of a response strategy and action plan. The province should also concentrate on building its capacity to avail itself of the opportunities presented by climate change, such as through the CDM. This will mean building regional and local authority platforms for interfacing with established national structures and for identifying and supporting local projects that qualify for the CDM. Furthermore, there is significant innovative capacity in the province that can be supported and commercialised on a climate change platform.

On a compliance level, the Western Cape should position itself proactively for meeting compliance based obligations that South Africa has committed itself to and to plan for future obligations that may arise, such as post 2012 greenhouse gas emission reduction targets. The Western Cape should strive to maintain its status as a relatively low GHG emitter even in the face of anticipated economic and population growth.

Legislative overview of the environmental regime

Overview[51]

The Western Cape Province's Department of Environmental Affairs and Development Planning (the "Department") has embarked upon a strategy to regulate and/or manage some of the negative impacts of climate change by developing a strategy and action plan. In this context, it is important to understand the nature and extent of the policy promulgated under specific legislation and in particular its legal consequences.

The "provincial climate change response strategy and action plan" is not necessarily in law a policy. However it does constitute a deliverable in that stakeholders have been informed and consulted in the development of the strategy and as such have a legal right (and legitimate expectation) to expect performance from the government of the Western Cape.

Aside from ensuring the right to an environment that is not harmful to health or well-being, section 24(b) of the Constitution[52] places a duty on the state to protect the environment. This is to be achieved by reasonable legislative and other measures. In this context, "other measures" refers to administrative measures to be employed by the state in ensuring the protection of the environment, including the production of policies, strategic documents, action plans and the like.

Current thinking by national government responsible for atmospheric / climatic issues and their legal regulation seems to suggest that a specific Act of Parliament to deal with climate change in South Africa is not warranted by present circumstances[53]. It is, however suggested that specific amendments could be made to other laws which embrace environmental issues, so that climate change provisions are included.
It is furthermore national government's position at present that it is unlikely that legal provisions should prescribe specific methods and principles by which climate change adaptation and mitigation actions should be brought about. It is stated, rather, that legal provisions should set out the broad objectives of providing for climate change actions with the established linkages to other sectors[54].

International legal policy frameworks

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[51] This summary represents a synopsis of two documents respectively entitled "*Legal Review (Part 1): Overview of the Environmental Legislative Regime in relation to a Western Cape Provincial Response Strategy to Climate Change*" (draft dated 16 January 2007) and "*Legal Review (Part 2) Overview of the Environmental Legislative Regime in relation to a Western Cape Provincial Response Strategy to Climate Change: Response to Focussed Questions raised during the Consultancy*" (draft dated 9 February 2007) prepared on behalf of OneWorld Sustainable Investments by Smith Ndlovu & Summers Attorneys.
[52] Constitution of the Republic of South Africa, 1996.
[53] Publication by the Department of Environmental Affairs and Tourism entitled "South African National Climate Change Response Strategy" September 2004, pages 29-30.
[54] Ibid.

The United Nations Framework Convention on Climate Change (the "Climate Change Convention") defines "climate change" as "… a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere, and which is in addition to natural climate variability observed over comparable time periods".[55] It considers "adverse effects of climate change" as "… changes in the physical environment or biota resulting from climate change which will have significant deleterious effects on the composition, resilience or productivity of natural managed ecosystems or on the operation of socio-economic systems or on human health and welfare".[56]
The ultimate objective of the Climate Change Convention is:

> "*…to achieve, in accordance with the relevant provisions of the Convention, stabilisation of green-house gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system…*"[57]

The Kyoto Protocol (which was produced in 1997) elaborates upon the Climate Change Convention by placing more specific obligations on developed countries and what are described as "Countries with Economies in Transition". More particularly, Parties to Annex 1 (developed countries) of the Climate Change Convention are obliged to reduce their overall emissions of six greenhouse gases to at least 5 percent below 1990 levels between 2008 and 2012, while non-Annex 1 Parties (developing countries, which include South Africa) do not have to make any comparable cuts unless they choose to do so during that time period, whereafter the situation will be reviewed.

The South African legislation framework

The Constitution's environmental clause in the Bill of Rights[58] provides as follows:

> *"Everyone has the right –*
> *(a) To an environment which is not harmful to their health or well-being;*
> *(b) To have the environment protected for the benefit of present and future generations through reasonable legislative and other measures that:*
> *(i) prevent pollution and ecological degradation;*
> *(ii) promote conservation; and*
> *(iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development."*

Aside from the Bill of Rights it is important to understand the administrative framework which is established in the Constitution. The National Government and the Provincial Government are both entitled to legislate on matters stipulated in Schedule 4 to the Constitution. Both spheres of Government have legislative competence over areas that will impact on management in the natural/urban interface, like disaster management.

The National Environmental Management Act, 107 of 1998 ("NEMA") is the most significant single piece of legislation dealing with environmental management in South Africa.
NEMA contains certain fundamental principles which organs of state must adhere to and states, *inter alia*, that negative impacts on the environment and on people's environmental rights be anticipated and prevented, and where they cannot be altogether prevented, are minimised and remedied and that global and international responsibilities relating to the environment must be discharged in the national interest.[59]

[55] Article 1(2).
[56] Article 1(1).
[57] Article 2.
[58] Section 24.
[59] Section 2(4)(n) of NEMA.

Although the issue of climate change is not directly addressed in NEMA, the injunction upon all organs of state whose actions may significantly affect the environment to apply the principles contained in section 2 of NEMA, applies to the actions to be taken by National and Provincial Government in relation to the preparation of policy and response strategies to deal with the anticipated effects of climate change.

In terms of section 11(2) of NEMA, certain National Government departments that exercise functions involving the management of the environment, must prepare Environmental Management Plans (EMPs).

The provisions of NEMA in relation to the preparation and submission of EMPs by National Government departments clearly allow for climate change considerations to be incorporated in such departments' (four-yearly) EMPs. It has to be emphasised that all organs of state have to adhere to and apply the principles as stated in section 2 of NEMA when performing actions that may significantly affect the environment (such as preparing EMPs).

Since 3 July 2006 the procedural and substantive requirements for Environmental Impact Assessments (EIAs) in South Africa are dealt with in accordance with the provisions contained in NEMA and the NEMA EIA Regulations.[60] The NEMA EIA Regulations include: lists of activities which require either "basic assessment"[61] or "scoping and environmental impact assessment";[62] and procedural and substantive requirements of EIAs and the issue of environmental authorisations.

It is clear from the wording of the NEMA EIA Regulations that the list of factors to be taken into account by the relevant authority in granting (or refusing) an authorisation in terms of the provisions of NEMA is not exhaustive. Relevant considerations in relation to the anticipated effects of climate change may (and upon a proper interpretation of the wording of Regulation 8 must) therefore have to be submitted before, and considered by the relevant authority tasked with granting environmental authorisations.

The National Environmental Management: Air Quality Act, 2004[63] creates a framework to progressively "*reform the law regulating air quality in order to protect the environment by providing reasonable measures for the prevention of pollution and ecological degradation and for securing ecologically sustainable development while promoting justifiable economic and social development*".

The transition from the old Atmospheric Pollution Prevention Act[64] to the wholesale commencement and operation of the Air Quality Act is still in its formative stages and it is still unclear whether the new Act will be more effective and efficient in regulating air pollution.

The National Water Act, 36 of 1998 together with the Water Services Act, 108 of 1997 provides South Africa with a holistic and cohesive body of statutory water law. The National Water Act does not directly address a response strategy to water shortages that may occur as a result of climate change. It does, however, create a broad framework that creates flexibility for dealing with anticipated consequences of the phenomenon.

It is expected that the effects of climate change will lead to increased occurrences of veld fires. **The National Veld and Forest Fire Act 101 of 1998 (the "NVFFA")** aims to achieve effective veldfire management through, in the first place, prevention and secondly, combating of veld, forest and mountain fires when these occur. It therefore contains both preventative and fire-fighting provisions. It defines the expression "veldfire" to include forest and mountain fires.

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[60] Published respectively in Government Notices R385, 386 and 387 in *Government Gazette* 28753 dated 21 April 2006.
[61] R386 in *Government Gazette* 28753 dated 21 April 2006.
[62] R387 in *Government Gazette* 28753 dated 21 April 2006.

[63] Act 39 of 2004.
[64] Act 45 of 1965.

The Disaster Management Act, 57 of 2002 requires an integrated and co-ordinated policy that focuses on preparedness for disasters, rapid and effective response to disasters and post-disaster recovery and rehabilitation. When a significant event or disaster occurs or is threatening to occur, it is imperative that there should be no confusion as to roles, responsibilities, funding arrangements and the procedures to be followed.

The National Environmental Management: Integrated Coastal Management Bill (the "ICM Bill") expressly refers to the issue of climate change and responds to the threat thereof in terms of anticipated rise in sea-level by establishing a coastal buffer zone inland of the high-water mark, within which activities will be controlled and certain activities will be prohibited.[65] A further measure implemented by the Bill to respond to sea-level rise, is the establishment of so-called coastal set-back lines.[66] Set-back lines will be established in order to prohibit or restrict the building, erection, alteration or extension of structures that are wholly or partially towards the seaward side of such a coastal set-back line. These measures provide government with the power to prevent development that is too close to the sea-shore and will therefore mitigate the effects of possible sea-level rise.

The ICM Bill further contains an interesting provision regarding possible changes in the position of the high-water mark. It states that if the high-water mark moves inland due to erosion of the coast, sea-level rise or other natural causes, the owner of land situated inland of the high-water mark loses ownership of any portion of that land that becomes situated below the high-water mark and will not be entitled to compensation for the loss of property.[67]

The Marine Living Resources Act, 18 of 1998 does not specifically address or mention the possible effects of climate change on the commercial fishing industry but does provide for certain mechanisms by which threats to the industry emanating from the anticipated effects of climate change may be addressed. The MLRA enables the Minister to manage these effects by suspending or restricting any fishing activities which may further exacerbate the emergency.

The Municipal Systems Act, 32 of 2000 (the "MSA") specifies that municipalities must draw up an **Integrated Development Plan (IDP)** as a single, inclusive and strategic development plan that must be aligned with other municipalities and other spheres of government.[68] IDPs must comply with the provisions of the **Municipal Finance Management Act, 56 of 2003**.

Section 26 of the MSA specifies that certain requirements must be adhered to in the drafting of an IDP, including that an IDP must reflect: the vision for the long term development of the municipality with special emphasis on the municipality's most critical development and internal transformation needs; the council's development strategies which must be aligned with any national or provincial sectoral plans and planning requirements binding on the municipality in terms of legislation; and applicable disaster management plans.[69] It seems clear that the MSA already provides for the drafting and amendment of IDPs to cater for the anticipated and real effects of climate change.

Implications for municipalities

It is therefore incumbent on municipalities that, should any provincial strategy or action plan be formed in relation to climate change by the relevant organs of state within the Western Cape Provincial Government, such municipalities would have to appropriately amend and align their IDPs to give effect thereto.

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[65] Section 16 of the ICM Bill.
[66] Section 25 of the ICM Bill.

[67] Section 14 of the ICM Bill.
[68] Chapter 5 of the MSA.
[69] Section 26 of the MSA.

Although no direct reference is made to conflicts between national legislation, section 150 of the Constitution states that, when considering an apparent conflict between national and provincial legislation, or between national legislation and a provincial constitution, every court must prefer any reasonable interpretation of the legislation or constitution that avoids conflict.

It can be argued (by analogy) that a court, when considering a possible conflict between different pieces of national legislation, must prefer any reasonable interpretation which avoids a conflict to any alternative interpretation that would result in a conflict.

Although the environmental right enshrined in the Constitution (which is the supreme law of the Republic and with which all other laws and conduct must be consistent)[70] provides far-reaching entitlements in relation to the environment, it is doubtful whether a legislative review (or overhaul) of South Africa's environmental laws in order specifically to address climate change will be embarked upon in the near future. In the absence of any clear indication that the legislative systems in place in South Africa do not adequately deal with the anticipated problems associated with climate change, it is highly unlikely that such a legislative review will take place any time in the near future.

It is submitted that the development of policy with regard to the implementation of certain provisions designated to be dealt with by organs of state in the provincial sphere of government[71] under (*inter alia*) the National Environmental Management: Air Quality Act, 39 of 2004 (the "AQA"), will be of substantial significance with regard to the Western Cape provincial government formulating a successful response strategy to climate change.

It must also be noted that the formulation and implementation of policy measures (if properly applied) is of great value to administrative decision-makers (among others) in that it creates the necessary framework whereby provincial organs of state can easily respond to environmental pressures without organs of state having to go through the slow process of having legislation enacted.

Recommendation

It is crucial for the Department to be reminded that the production and proposed use of strategy and response to climate change must be undertaken through vigorous implementation. In the event that, for example, decisions are made by governmental departments that could impact negatively on the environmental right, and that substantially affect the environment or cause pollution, and those decisions are taken without reference to underlying policy documents such as an action plan to combat climate change, then they might be susceptible to challenge. That challenge is regulated primarily by the internal appeal provisions set out in a range of national legislation[72] and, once those internal appeal remedies have been exhausted, by the challenge of those decisions in review applications made to South Africa's High Court. The procedure for review applications together with a range of other features relevant to them including the substantive bases on which a Judge of the High Court can set aside decisions that are unlawfully taken, are stipulated in the Promotion of Administrative Justice Act, 3 of 2000.

The "provincial climate change response strategy and action plan" is not necessarily in law a policy. However it does constitute a deliverable in that

[70] In terms of section 2 of the Constitution.
[71] See section 4(2)(b) of the AQA.
[72] For example, section 35 of the Environment Conservation Act, 73 of 1980 and section 43 of the National Environmental Management Act, 107 of 1998.

stakeholders have been informed and consulted in the development of the strategy and as such have a legal right (and legitimate expectation) to expect performance from the government of the Western Cape.

Communications, education and awareness

A perceptions audit conducted across the province would provide clarity as to the status quo of climate change awareness amongst the general public, industry, community and government stakeholders. However, an analysis can be drawn from observing the media coverage of the challenge and from observed response thereto. In addition, observations have been made throughout the process of developing the strategy and from the stakeholder engagement process which has informed it.

The launch locally of the Al Gore movie titled *An Inconvenient Truth* was certainly timely as the screening and the ensuing debate has raised levels of awareness and (more importantly) understanding and knowledge of the underlying issues and climate science that is resulting in global warming. An important lesson to be gained from the movie lies in its ability to bring a seemingly complex issue to a level that can be understood easily at a 'layperson's' level.

The Nicholas Stern Report on the global economics of climate change, which was also launched during the timeframe of developing a provincial response to climate change, has also received wide publicity and review in most major newspapers and news channels locally. The report has brought a socio-economic context to the issue of climate change that is almost unprecedented, and the ensuing debate has highlighted an issue that has hitherto, in most minds, been considered primarily in scientific terms. The result has been that many corners of society are thinking about local consequences – and costs – of climate change, particularly given that the report highlights adaptation requirements in Africa as requiring emphasis. Sir Nicholas Stern's visit to South Africa earlier this year heightened the focus.

More days than not sees media coverage in some form of the issue of global warming and its impacts. This ranges from debates with so-called 'sceptics' on whether or not climate change is indeed an issue to a focus on specifics such as climate change implications for the Cape Winelands[73]. Articles in turn spawn letters to the press and responses – both 'for' and 'against'. Then there have been numerous radio interviews and debates, such as the 'After 8 Debate' on SAFM, which included a panel on climate change followed by comments and questions from the public.

All of these activities can only serve to heighten awareness and it is apparent from many correspondents from the general public that the issue is receiving attention. This is in the form of both arguing against the possibility of climate change through to serious consideration of "what can we, as individuals do about it?"

Media coverage is more about global warming – on a global scale – than it is about the impacts for the Western Cape. Whilst the global context is extremely important, constant focus on this serves only to distance the problem and therefore the solution. This leaves the province's people with the sense that this is "not our problem".

[73] Refer to Leonie Joubert's article in the Sunday Independent on 29 April 2007.

Recommendation
A communications, education and awareness strategy should build on existing knowledge and bring attention and focus to the impacts of climate change on the Western Cape and what the province is doing and can do to adapt and mitigate.

Socio-economic challenges in the Western Cape

Provincial socio-economic vulnerability

The Western Cape economy is diverse and supports important activities in the primary, secondary and tertiary sectors of the economy**.** The province accounts for 14.5% of South Africa's GDP.

It is expected that the Western Cape will be most vulnerable in the commercial agriculture and fishing sectors, as well as the livelihoods in poorer and more rural areas (DEADP 2005). The transport and water and energy sectors were also selected for further analysis, as well as tourism activities.

The direct contribution of the agricultural forestry and fishing sector to the provincial GDP is at 4.5% (WCPT 2006), which is higher than the national average of around 3%. Almost 20% of the Western Cape's exports are from the agriculture, forestry and fishing sector, with a further 13.4% in the food, beverages and tobacco sector (WCPT 2006). When agro-processing activities are included, exports related to agriculture and fishing may be in the order of half the total exports. The agriculture, forestry and fishing sector employed a relatively high number of people when compared to output, initially at increasing levels, although later at declining levels.

In 1996, ***employment*** was at 13.4% of total employed in the Western Cape, in 2001 at 15.3% and in 2004 estimated at 9% (WCPT 2006, Wesgro). In 2000, employment is estimated to have totalled 235 000 individuals, declining to 152 000 by 2004, a decline of 83 000 individuals, equivalent to an annual reduction of over 10 per cent in employment in the primary sector (WCPT 2006). **The agriculture sector has been a growth employer in the Western Cape[74].** The agriculture, forestry and fishing sector is the biggest employer by far in the West Coast (40%), Cape Winelands (38%), Overberg (37%) and the Central Karoo (30%). The transport and communication sector employs only 5% of the economically active population in the Central Karoo, followed by Eden and the West Coast each at 3%, and Overberg and the Winelands each at 2%. The electricity and water sector is not a significant employer in any of the regions.

There is ***inequality in distribution of assets*** across the Western Cape province. The growth in the distribution in assets such as housing, piped water, electricity for lighting and sanitation differ markedly across the population. In the case of formal dwellings and access to piped water, some of the lower percentiles of the population even experienced negative growth between 1993 and 2004.

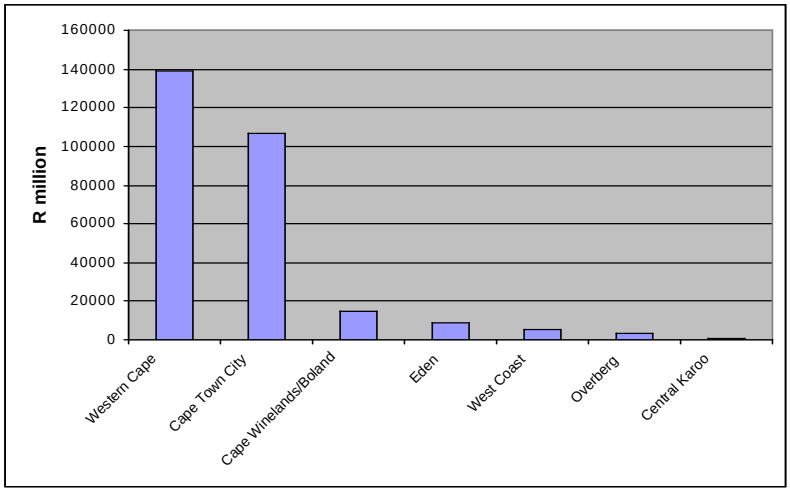
[74] Although employment figures have dropped, the sector has grown overall in relation to other sectors.

Regional vulnerability

Although it is evident that the agricultural sector is in decline relative to the rest of the Western Cape economy, the spatial variation in this trend is important when analysing local vulnerability and adaptive capacity.

Contribution to output is primarily from Cape Town with more than three-quarters (77%) of all commercial economic activity in the Western Cape occurring in the City of Cape Town, with a further 10% in the Cape Winelands/Boland area. Eden accounts for 6%, the West Coast 4%, Overberg 2.5% and the Central Karoo 0.5% (see Figure 23).

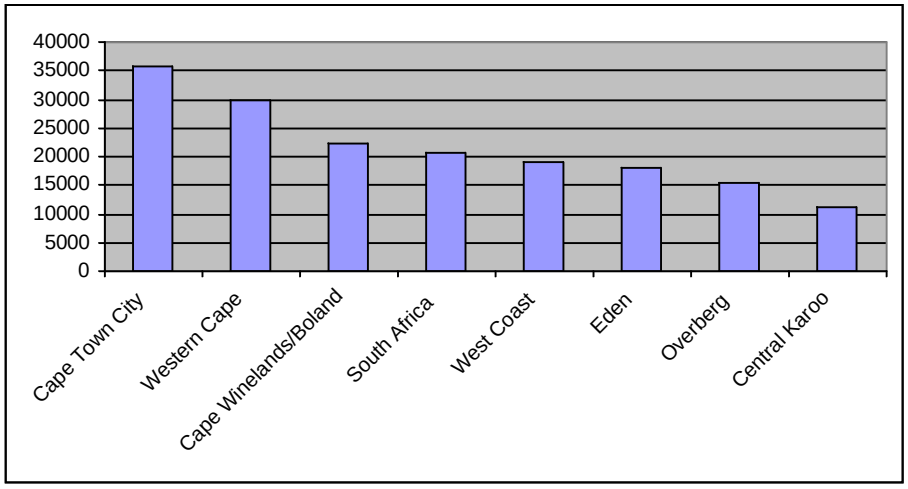
Figure 23: GDP per region (R million, current prices 2004)



Source: Wesgro 2004

When expressed in GDP per capita terms, it is clear that the city of Cape Town, the Western Cape as a whole and the Cape Winelands have higher GDP/capita than the average for South Africa, while the West Coast, Eden, Overberg and the Central Karoo all have a lower GDP/capita than the national average (see Figure 24).

Figure 24: GDP per capita (Rand per annum, 2004)



Source: Wesgro, 2004

The relative vulnerability within these areas is worth considering. Analysis shows that regional economies are much more dependent on agriculture, forestry and fishing than the province as a whole, making some regions and therefore provincial populations and communities more vulnerable to the negative impacts of climate change than others.

This is especially so for the Overberg (21% of GDP), West Coast (19%), Cape Winelands (14%) and to a lesser extent the Central Karoo (10%) and Eden (7%). The direction of change and not only the share of output is important when assessing vulnerability. ***The agriculture, forestry and fishing sector is only growing notably in Eden (2.6%) and on the West Coast (2.3%)***.

The impacts of climate change on economic sectors will be felt in terms of ***employment.*** The agriculture, forestry and fishing sector is the biggest employer by far in the West Coast (40%), Cape Winelands (38%), Overberg (37%) and the Central Karoo (30%).

An *analysis of development indices* reveals inequalities in rates of development across the province and areas with the lowest scores on the human development index (HDI)[75] as well as the city development index (CDI)[76] are suspected to be the most vulnerable to change. The general result from this analysis is that the City of Cape Town, with higher HDI and CDI scores, is more likely to cope better with change than the more rural areas. In most cases the CDI is higher then the HDI, with the notable exception of Prince Albert and Witzenberg. This is pertinently so for areas like Beaufort West, George, Mossel Bay, Elsies River, Kraaifontein, Cape Agulhas and Saldanha Bay.

Access to income is also an indicator to consider in assessing vulnerability. The percentage of households with no income is highest in Stellenbosch (20%), followed by three areas in Eden, namely Knysna, Plettenberg Bay and George at 14% each. Cape Town City follows with 13%.

Education is a further factor and the highest incidence of a relatively uneducated workforce is found in the Breede River DMA (89%). This is followed by Witzenberg (80%), Theewaterskloof (79%), Cederberg (79%), Prince Albert (78%), Kannaland (78%), Breede River (77%), Laingsburg (76%) and Berg River (76%).

System strengthening

The determinants of adaptive capacity include:

- income (GDP/capita)
- proportion of the population without any source of income - as a proxy for the extent of poverty
- extent of income inequality (based on Gini coefficient)
- proportion of working population with less than Grade 7 qualification
- share of output contributed by agriculture

Based on evidence and research[77], the economic sectors that will be directly affected by climate change are agriculture (due to impacts on water resources) and fisheries (due to migrating fishing stock). Many Western Cape rural communities are dependent on agriculture and/or fishing for their livelihoods. This makes it difficult to envisage a future Western Cape that has diversity in economic dependence and livelihoods. Without foreseeable replacement industries/economies, it is not unreasonable to assume that rural livelihoods as we know them now will migrate to already burdened cities.

Table 12 provides a summary of direct and indirect socio-economic impacts of climate change on the Western Cape, as depicted in the status quo review (DEA&DP 2005).

[75] The Human Development Index (HDI) is a composite index of health, education and income.
[76] The City Development Index (CDI) is a composite index of infrastructure, waste, health, education and income.
[77] See Part 1: Risk and Vulnerability Assessments of vulnerable sectors and resources of the Western Cape; and Appendix 1: PESTLE analyses of sectors and resources of the Western Cape.

Table 12: Direct and indirect socio-economic impacts of climate change on the Western Cape (as depicted in DEA&DP 2005)

Socio-economic sector	**Functional relationships between climate change and economic activity**	**Possible Impacts**
Agriculture	Photosynthesis, colour development, cold winters, rain season, low heat stress, water availability	Loss in volume (yields) and quality of production Vulnerability of these agricultural products to changes in temperature and precipitation on a site-specific level such as the Western Cape is the focus of another part of this study
Fishing	Fish growth dependant on availability of food and differences in temperatures Important climate features include temperature, wind (speed and direction), the shifting of streams and currents (upwelling), sea level rise, availability of sunlight, the occurrence of storms and freshwater run-off into the marine environment Loss of habitat, migration to new habitats, invasion of new species	Fisheries productivity of estuaries correlated strongly with size and mouth conditions, estimated that up to 18% of inshore fisheries, or around R450 million per annum, is already lost due to a change in estuarine functioning Fish processing affected by varying yields in other parts of South Africa
Forestry	Reduction of inhabitable range	Little impact - forestry small in comparison to the rest of country, and major softwood species, *Pinus Radiate*, is phased out
Manufacturing and industry	Changes in supplies, employment, operations, and customer preferences	Most directly impacted are processes adding value to renewable natural resources: agro- and fish processing, furniture, pulp and paper sectors Some businesses positively impacted by climatic changes: • climate control • water conservation and recycling • defensive construction • water supply options Impacts of government policies, such as carbon taxes

		Customer preferences may change due to climatic changes, for example clothing and recreation
Tourism	Length of the season may be affected by changing temperatures and precipitation Rise in sea-level could lead to a loss of resources such as bathing beaches Reduction in stream-flow run-off could limit water sports and recreational fisheries Changing ecosystems could impact niche-market activities such as bird/whale watching Knock-on effects would occur in sectors that are dependent on tourism demand, such as transport, restaurants, agricultural products, crafts and small business services such as tour operators	Peak arrivals in April and December not directly affected by predicted changes in rainfall Warmer and drier summers can have implications such as droughts and fires, water shortages and poor urban air quality Heat stress affects mostly the elderly and small children Changes in rainfall patterns affecting supply of water and ability to meet growing tourism demand Link between species richness and macro tourism value may not be that strong on macro level Increasing trend in extreme events such as flash floods could also impact negatively on tourism in specific areas
Finance and investment	Private and public institutions that offer insurance, disaster preparedness/ recovery, banking and asset management services	Impacts on insurance: • Weather-related losses account for 75% of the economic and 87% of the insured losses worldwide • Flooding events in Western Cape Banks and asset management may be impacted through • impacts on underlying secured assets (e.g. property losses due to weather-related disasters) • impacts on credit applications that may not prove to be viable (e.g. tourism ventures impacted by beach degradation) • impacts on investments (e.g. flooding, vulnerable agricultural ventures)
Transport, communication and trade	Deterioration of physical infrastructure, risks to coastal roads	Transport and communications infrastructure may be physically influenced be extreme events, such as flooding and sea-level rise

	Change in transport patterns Change in frequency of accidents Change in volume and quality of products traded Government actions on emissions, such as carbon taxes, increasing the costs of transport	Sustained higher temperatures could have damaging impacts on roads such as asphalt Heat could also have an effect on aircraft down times, as there is a lack of lift in the air Drier conditions signal less road accidents, although rain events during drier conditions produce a greater frequency of accidents and injuries Seaports and airports will be disrupted by windstorms and other extreme events Any trade activity, depending on exposure to climate risk, could be impacted.
Construction	Sea level may lead to property damage, beach degradation and habitat loss. Physical impacts on infrastructure	Four particularly sensitive regions in South Africa, two of which occur in the Western Cape: Greater Cape Town (Melkbosstrand to Gordon's Bay) and the south coast (Mossel Bay to Nature's Valley) Popularity of beaches among domestic tourists suggests a potentially vulnerable socio-economic activity

Major sources: IPCC (2001), Kiker (1999), Turpie, Winkler & Midley (2004), Munasinghe (1995) as presented in DEADP (2005).

Recommendation
Adaptive capacity needs to be strengthened across the Western Cape to establish the means to cope with climate change impacts. It is evident that some regions and towns are currently more vulnerable than others, which creates a justifiable basis for prioritisation when considering action and implementing the response strategy and action plan. Vulnerable areas need to be assessed against a backdrop of stress factors and the related depletion of natural and economic resources (examples include water, agriculture and fisheries). The development of socio-economic scenarios against climate change indicators will provide a useful decision-making tool for policy makers and strategy implementers.

Part 3

Approach and Methodology

Part 3: Approach and Methodology

1. Overview

Stakeholder consultation, international best practice, a comprehensive literature review and expert opinion has informed much of the work in developing the strategy. A critical success factor for the roll-out of the response strategy is its integration with other, relevant strategic planning processes and initiatives, planned and future, in the Western Cape and nationally. A close review of these therefore further underpinned the strategy development.

Climate science analysis provided the basis for assessing impacts and thus developing the adaptation and mitigation strategy, requiring the use of climate models, global emission scenario models and then applying multi-disciplinary approaches in linking these models to spatial models such as biodiversity and crop productivity and testing sensitivity thresholds of the prioritised, vulnerable natural and human systems. Climate science modeling information is represented through a set of robust statements about expected climate change in the Western Cape and some climate scenarios (i.e. outlines of future climate development for the WC). These have been assessed as integrated with socio-economic models for the province - comprising environmental changes linked with socio-economic changes - so as to provide the context in which climate change will have its impact.

Stakeholder engagement and discussions were used to provide a rapid assessment of the key issues and priorities as perceived by experts in the related fields, politicians, local authorities and strategy administrators, industry players and communities. Stakeholder engagement also provided the platform for developing the communication strategy and awareness campaigns.

International best practice and literature review facilitated the assessment of countries and regions that face similar bio-physical and / or socio-economic challenges to the Western Cape. Possible partnerships with countries/regions identified such as Peru, Chile, Western Australia, California, Morocco and Queensland can assist the province significantly in its ability to leapfrog certain research and assessment processes and to deal more robustly and cost effectively with climate change risks. The Western Cape is fortunate in that it is home to strong research, scientific and socio-economic analytical ***expertise*** and is the residence of some of the international community's renowned climate scientists and policy-makers. This provides a sound platform for accessing international research and the critical success factor lies in the ability to identify suitable partnerships.

A response options matrix *consisting of* around 280 possible response options – both mitigation and adaptation – emerged from the research, stakeholder consultations and expert review processes that populate the matrix. These are grouped for ease of reference on a sectoral / systems basis. These sectors and systems each underwent risk and vulnerability assessments which were informed by research and analysis in each cluster, based on the application of a framework that examined political, economic, social, technological, legal and environmental indicators (PESTLE analysis). This facilitated the basis for an initial level of prioritisation within sectors and systems based on understanding of the sensitivities and adaptive capacities within each.

Prioritising and evaluating options

A multi-criteria analysis approach encompassing economic, social, environmental and 'ease of implementation' criteria has been applied to the extensive matrix.

2. Theory of economics of climate change

Cost-benefit approach or efficiency criterion

The literature on the subject categorises traditional responses to the problem of climate change in the cost-benefit analysis (CBA) framework and the sustainability framework (Bowers 1997; Pearce 1998:326-335). The CBA approach is founded in welfare economic theory. CBA analysis can be used to compare private, economic or social cost and benefits, largely depending on the objectives of the conducting agent. An extended CBA can also take account of distributional aspects, but this has not been applied in practice often (Squire & van der Tak 1975). Increasing complexity in the estimation of benefits, i.e. monetary valuation of a change in environmental quality, has led to a broader family of decision-making techniques (Jepma & Munasinghe 1998). In a broader sense, CBA analysis includes the cost-effectiveness approach (CEA), multi-criteria approach (MCA) and decision analysis (DA). The CEA approach is used when benefits are constant or are not available in a format that can be compared to the costs of a particular project or policy. The CEA reduces to finding the lowest cost solution to meet a particular level of benefits. The MCA approach, like the CBA approach, is a trade-off between costs and benefits, but allows for less rigorous representation of the cost and benefits. To place an economic value on environmental damages is often problematic and multiple objectives are compared to a set of selection criteria. In DA the focus is on making decisions under uncertainty. This approach provides a systematic method of solving complicated problems.

Making decisions about climate change involves determining the appropriate level of abatement and adaptation (Pearce 1998:326). A framework for analysis is needed to set these levels. Pearce distinguishes between two broad perspectives on the way benefits and costs should be compared, namely:

- judgemental CBA framework
- monetised CBA framework

In the first approach, gains and losses are compared without reducing them to common units. One should think of either the CEA approach, where benefits are not expressed in a common unit to the costs, or a MCA approach, where multiple objectives are not reduced to a common unit. In a monetised CBA framework, however, benefits and costs are reduced to the same monetary unit to permit direct comparison as far as this monetisation is credible. These benefits and costs are expressed in terms of human preferences. Future generations are included at least insofar as they are assumed to want what the current generation wants.

The CBA framework has been applied extensively in the economic analysis on climate change. While these models do not provide (or attempt to provide) a final answer on climate change, they do provide useful insights in understanding the economics of climate change (Tol 1995). The many underlying assumptions and simplifications, although necessary when modelling a very complex problem, have to be borne in mind when applying the results in the policy arena.

Several key assumptions must be made when assessing the cost and benefits of action on global climate change. The added complexities of the climate change problem include high scientific, economic and technological uncertainties, potential irreversibilities, non-linear causal chains, a very long timing horizon and the global scale of the problem - with varying regional implications. Ethical and social limits to economics are also problematic to include in CBA analysis. The distribution of costs and benefits, a key element of the social limits to economic growth, is a detrimental factor in policy-making and one that has not received adequate attention in the CBA approach. Passing the CBA test is neither necessary, nor sufficient to predict that a policy will be

accepted in the political process. This is because the aggregated costs and benefits do not tell us anything about who enjoys the benefits or bears the costs (Bradford 1997:2). A CBA on climate change, whether correctly discounted or not, is unlikely to provide enough information for predicting or guiding choices. What needs to be added is information about the distribution of gains and losses over time and across space (Bradford 1997:9). However, despite these complications, a CBA is still very helpful in making decisions on even such complex issues as global climate change (Bradford 1997:10), given that sufficient data on both costs and benefits are available to perform such an analysis.

Sustainability framework

In the evaluation of the CBA approach to economic policy on climate change, nothing has been said about biophysical limits and the laws of thermodynamics. The second broad approach to economic policy on climate change, namely the sustainability framework, gives highest priority to the avoidance of unacceptable damages to future generations and is discussed separately here. This issue is perceived by some to be especially relevant in the context of the problem of global climate change as highly probable. However, one should not lose sight of the potential loss of current generations and that a cautious approach to future damages involves some trade-offs for current and future generations.

Within the sustainability approach there are two dominant views:

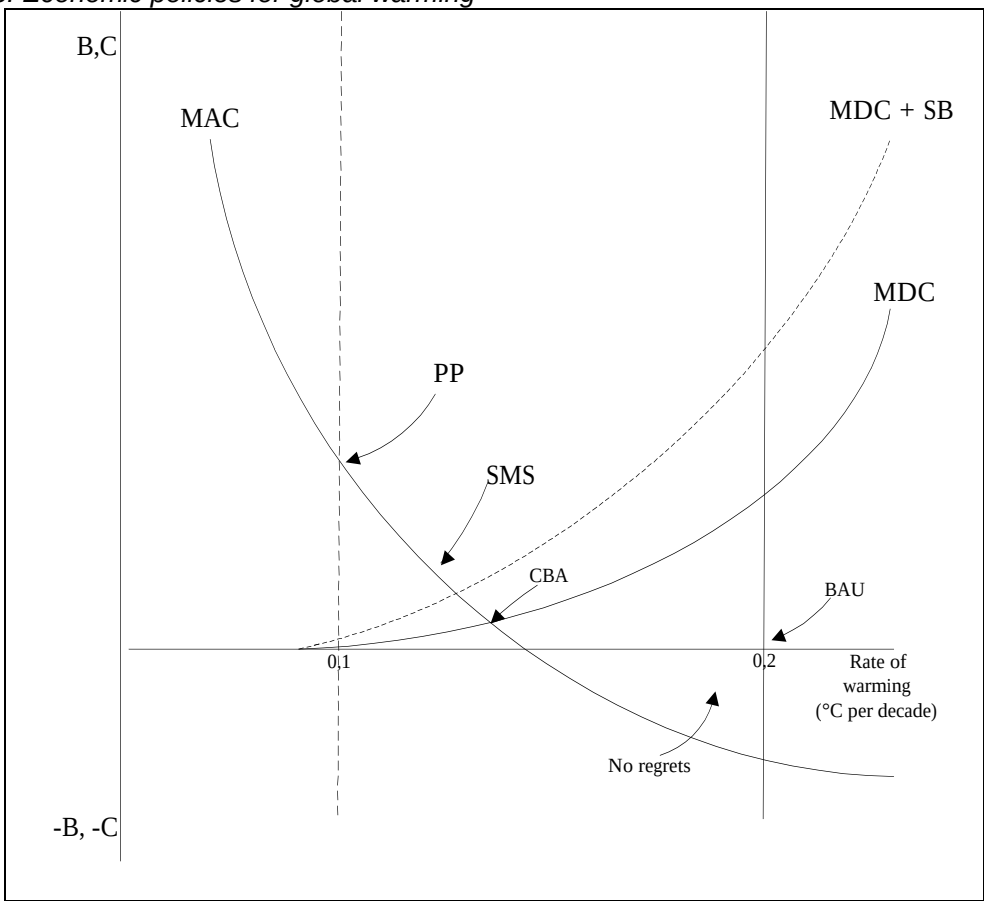
- absolute standards approach
- safe minimum standards approach

In the first approach, the cost of damage control is irrelevant. It is perceived that the benefits of control are so large that it is not even worth bothering about valuing these damages. In the second approach, this position is watered down a bit by accepting the decision/rule that damages should be avoided subject to the constraint that such avoidance does not itself impose an unacceptable cost. This approach aligns itself closely with the ecological economic notion of biophysical limits.

Economic response strategies for climate change

Neither of these traditional responses to the problem of climate change is non-controversial. Where the CBA framework requires a monetary valuation of uncertain and possibly irreversible impacts of often non-linear ecosystem feedbacks, the sustainability framework fails to take into account the trade-offs that have to be made between objectives (now and in the future). The policy impacts of the different frameworks are shown in Figure 25.

Figure 25: Economic policies for global warming



Source: Pearce (1998).

The business-as-usual (BAU) scenario means doing nothing and hence continuing to warm the earth by 0.2 °C per decade (assuming a 2°C increase in temperature by 2100. This will differ with various climate predictions but is only used for illustrative purposes here). A 'no-regrets' policy is aimed at implementing abatement and adaptation measures that have a negative cost. The CBA framework determines an optimal outcome where the marginal abatement costs (MAC) and marginal damage costs (MDC) of the control of global warming is equal. For a correct representation, the MAC should be equal to the MDC (including secondary benefits (SB)). The precautionary principle (PP) and the safe minimum standards (SMS) approach could in theory be the same if the opportunity costs of applying the SMS is not unacceptably high. The meaning of unacceptably high costs is indeterminate and the SMS is shown to be somewhere between the PP and CBA policy outcomes. The PP is identified with an avoidance of rates of warming in excess of a predetermined threshold, shown in Figure 25 as 0.1 °C. Figure 25 demonstrates the economic inefficiency of the PP, SMS and BAU approaches. 'No regret' policies are an essential first step but would not reach an economic efficiency where the MAC is equal to the MDC.

If economic efficiency were the only objective the CBA outcome would have been the ultimate policy solution. However, as indicated in the sustainability approach and the specific features of the problem of global climate change, a pure CBA outcome needs re-evaluation. Various analysts from different schools of thought on the economy-human activities-environment interactions have come forward with different theories and policy suggestions. With the ultimate objective of developing a policy for sustainable development with application to climate change, a way needs to be found where the benefit from both the efficiency and sustainability frameworks could be taken into

account. The potential contribution of more evolutionary approaches to climate change policy has not received attention in the development of control paradigms.

Application of economic assessment tools to the Climate Change Response Strategy and Action Plan project

Estimating benefit and cost functions

As was illustrated in Figure 25, any response strategy to climate change focussed on economic efficiency would aspire to a level of control where the marginal cost of control (mitigation and adaptation) equals the marginal benefits of doing so (damages avoided). Such an approach assumes that all incremental damages and costs are measurable in monetary terms. Given the long time horizons involved, and the spatial global spread of climate change, it is no trivial task to estimate such functions - especially on a regional level. No comprehensive and generally accepted results on the costs and benefits of responding to climate change in the Western Cape are available to inform a response strategy, although possible impacts are discussed in DEADP (2005). National-level preliminary estimates of unmitigated damage costs are only available as a research publication, and based on several critical assumptions that would need further research (see Turpie 2004). Internationally, current socio-economic modelling approaches are also far from finalised or generally accepted (Tol 2005). It can therefore be stated that further work is required in the Western Cape to make defendable statements on the benefits of climate change action. This study, which is focused on action and response, is also in no position to attempt to do so.

The absence of damage cost estimates is no excuse for inaction. In the Western Cape action and response strategy project, desired policies and measures are gathered through a stakeholder-led approach and prioritised using inputs from the literature reviews and expert opinion. This serves as a proxy for society's perceived need to protect against damages due to climate change. The costs of achieving these response options has been quantified for the highest ranking options.

Measuring adaptation costs

Adaptation to climate change includes *any adjustments that individuals, singly and collectively (in whatever organizational framework), make autonomously or policy makers undertake strategically to avoid (or benefit from) the direct and indirect effects of climate change. Individuals and organisations can do this autonomously in the sense that economic, social and political institutions with which they interact provide incentives for them to adjust automatically to climate change, without political intervention. Or, they can adapt strategically through decisions made by governments* (Callaway 2003).

This follows a distinction made by Smith and Hitz (2002), namely: *autonomous short-run adjustments in the behaviour of individuals and firms, autonomous market adjustments to climate change that indirectly affect human and organizational behaviour, and both autonomous and strategic long-run adjustments in technology, infrastructure and institutions.*

Adaptation benefits are the value of the climate change damages avoided by adaptation actions. Adaptation costs are the real resources society gives up (or the opportunity cost) to create adaptation benefits (Callaway 1999; Fankhauser, 1997).

For example, climatic change may lead to increasing costs of agricultural production (or in economic terms a negative externality). These adaptation costs are the difference between the baseline production costs at a certain existing climate and the increased production costs at a

certain altered climate. Adaptation costs that are already incurred at the current climate (in the baseline) do not count as additional costs of climate changes. Many adaptation options may not be sufficient to reach the welfare of a current climate scenario, and in such a case a net cost of climate change is imposed on the producer. However, if adaptation does take place some costs are incurred (adaptation costs) while some damages are avoided (adaptation benefits). This conceptual framework raises the important issue of baseline adaptation, an inherently contentious issue given the dynamic nature of climatic variability. An important question is the existing flexibility that individuals and organization already internalise in their activities or the ability to cope with climate variability. Such autonomous adaptations to the existing climate cannot be counted as additional damages due to climate change and need to be excluded from an adaptation costing study.

Another issue is related to the dynamic and complex nature of climate change: how to plan under such uncertainty and how to differentiate between long and short run adaptations (see also Callaway 2003). A practical action plan would therefore not be able to observe this framework in detail, but it does serve as a conceptual starting point.

There is limited literature on adaptation costs (Tol 2005, Callaway et al 1999). The IPCC's Third Assessment Report's main contributions in this area are a focus on qualitative assessment of adaptation capacities and potential win-win strategies and the relative rankings or detailed case-specific project/programme level costs analysis.

The costs of adaptation can best be evaluated on a qualitative basis using a ranking based on international literature and expert opinion, supported with a more quantified approach on selected high-priority interventions. However, this approach would not give an indication of the total opportunity cost to society of adapting to climate change.

To implement a strategy would require an analysis of the costs of responding and adapting. There are several ways in which adaptation costs have been quantified (Tol 2005):

- Models assuming that the impacted system does not autonomously respond to climate change.
- Models where adaptation is treated arbitrarily ('what if'), without an evaluation of realism or the desirability of the level and type of adaptation.
- Behavioural models where motives or rules are included, though postulated.
- Statistical models of adaptive behaviour measuring rather than postulating motives/rules.
- A small but increasing number of studies that look at past and current adaptation using the rich yet descriptive methods of anthropology, sociology, political science, social geography and history.

The latter approaches are more realistic than the earlier models that focused on impacts and arbitrary change where adaptation was addressed at the end of the analyses.

The approach taken in this study has been a combination of estimating adaptive capacity of local socio-economic systems and a more traditional partial cost-effective analysis on selected adaptation responses with qualitative analysis of the rest of the selected options. This informed decisions on where to direct facilitated adaptation and which options to pursue from a socio-economic perspective.

Table 13 provides an example of how the proposed monetary CEA on selected adaptation options could be carried out (These numbers are all fictitious). For example, climate change could lead to a loss in apple production of 200 000 tons. At current prices of R2 this is a possible damage of R400 000. Shade netting is an adaptation option, which would avoid 100 000 tons of loss at a cost of R1/ton. To do such an analysis, the following is required from non-economic specialists:

- a scientific quantification of climate change in terms of the variables important for the provisioning of goods and services (for example, changes in temperature, rainfall, wind under various projections)
- a scientific rationale for a change in the production of these goods and services provided due to this projected changing climate (for example, by using an input-output function)
- a selection of key adaptation options in various economic sectors, for specific activities and for managing resources
- a scientific motivation for the damages that can be avoided through the use of such adaptation options.

Table 13: Simplified example of adaptation cost analysis

Goods and Services a	Existing b (current climate)	Altered c (altered climate)	Unit Value d	Damage e (c-b)*d	Adapt option f	Adapt efficiency g1 (damage avoided)	Adapt efficiency g2 (damage avoided)	Adapt Cost h	Unit Cost Adapt i CEA
Agriculture	***tons***	***tons***	***R/ton***	***Rands***		***tons***	***%***	***Rands***	***Rand/ton***
Apples	100000	800000	2	1400000	Shade netting	100		100	1
Wheat	500000	250000	1	-250000	Boreholes	2500		5000	2
Water	***m3***	***m3***	***R/m3***			***m3***	***%***	***Rands***	***R/m3***
Freshwater supply	50000000	25000000	0.06	-1500000	Increase irrigation eff	10000		2000	0.2
	50000000	25000000	2	-50000000	Urban water conservation	5000000	20%	1000000	1
	50000000	25000000	0.06	-1500000	Irrigation water trading	25000		2500	0.1
	50000000	25000000	1.5	-37500000	Industrial demand reduction	2000		1000	0.5
Tourism	***number***					***number***	***%***	***Rands***	***R/trip***
Ecotourism trips	6000	3000	5000	-15000000	Season marketing	1500	50%	750000	1000

Notes:
Columns a,b,c,f,g1,g2: information to be supplied through stakeholder process, and non-economic experts
Columns e, i are calculations
Columns d, h to be estimated b socio-economic expert in consultation with experts and based on literature

It must be noted that this kind of effect on production approaches has been criticized for not capturing local autonomous adaptations, and for the indirect way in which impacts of climate change on productivity are estimated. This often leads to an overestimation of climate change impacts on production. Cross-sectional datasets with varying climate variables are, however, not available for the Western Cape - a possible gap for further research.

If such functions are known, better estimates of damages would be possible. In fact, the mathematical solution to the maximization of production subject to a range of key climate variables (e.g. rainfall, temperature, wind) and for different climate projections would be the theoretically more correct approach (see Callaway 2003), but not practical for this project due to data, time and resource constraints.

Measuring mitigation costs

The following analytical steps are common to mitigation cost assessments (Christensen & Sathaye 1999; UNEP 1994):

1. Construct baseline scenario
2. Identify mitigation options
3. Assessment of mitigation potential and costs of options
4. Construct mitigation scenarios, including multiple options
5. Assessment of policy scenarios.

The CDM process includes such project-based mitigation cost assessments as a standard procedure. In this study mitigation options have not all been specifically quantified, but opportunities under the CDM are highlighted for action.

Conclusions

The economic analysis for the Western Cape CCRAS used socio-economic analysis and tools in the following way:

- The benefits of adapting to climate change have not been estimated in a monetized framework. Instead the study relied on a stakeholder-led approach, supported by a literature review and expert opinion to estimate society's preferred options to respond to the anticipated damages of climate change. This approach is primarily the result of a lack of data and research on climate change damages in the Western Cape but is also informed by the inconclusive state of research and divergent application of economic damage cost modeling in international literature.
- A quantification of the cost-effectiveness of response options focused on selected high priority adaptation options and was further complemented by qualitative analysis on other selected adaptation options. This was informed by best available estimates of the losses due to climate change and adaptation benefits as made by experts in the relevant sectors (rather than socio-economic experts) in the research team.
- The benefits of using the CDM mechanism for mitigation were highlighted in a general way.

3. Stakeholder Process

Background and context

The political events of 1994 ushered in an era of hope for various stakeholder groups in South Africa and the region as a whole; hope that their voices would finally be heard in processes that involve their physical, social, cultural and economic environment. Current events are taking place against a global context where stakeholder protests at various key global decision making platforms like the G-8, Nepad and various UN platforms are increasing. It is significant that local stakeholders have some understanding of some of the contradictions global leadership has to grapple with and some of the competing interests and priorities that regional stakeholders have to deal with.

The month of December 2005 saw some 1300 protest events in the USA alone, in an attempt to force the American government to join global efforts at combating the proliferation of greenhouse gas emissions into the atmosphere (CBS News, 5 Dec 2005). The United States of America is a significant contributor of carbon dioxide into the atmosphere amongst developed nations, and continues to refuse to ratify the Kyoto Protocol. One of the reasons cited by the Bush administration for refusing to ratify Kyoto is that developing nations that produce large quantities of greenhouse gases (such as China and India) are exempt from targets set by Kyoto. The economic impact of limiting emissions of greenhouse gases into the atmosphere (by looking at alternative power generation technologies) is at the core of global discord around ratification and implementation of the Kyoto Protocol.

Protest action as cited above is one form of stakeholder engagement in the global warming dialogue, probably the least appreciable, and mostly employed when there is total breakdown of dialogue and trust. The Southern Africa region has seen this scale of protest action in dealing with political challenges, and not on the subject of global warming. Does this mean our stakeholder engagement processes in global warming are better than elsewhere in the world?

The Western Cape government responded to the results of the 2005 Status Quo study (Midgley *et al,* 2005) on the region's vulnerability to climate change, by commissioning a service provider to draft the region's climate change strategy and action plan. The terms of reference for this work are emphatic on ensuring that various stakeholders participate in this work. The terms of reference specifically allude to the employment of the Western Cape Provincial Development Council (PDC) as one of available platforms that seek to enhance the participation of various interest groups in issues affecting the development of the region.

The Provincial Development Council (PDC) is a Western Cape government initiative located under the Department of Environmental Affairs and Development Planning. Its core mandate is to facilitate the participation of government, business, labour and civil society in issues affecting the development of all aspects of the people and environment of the Western Cape region. The PDC social partnership mechanism is the only formal structure in the region that includes various representatives drawn from the four social partners with a mandate to address regional challenges.

The existence of the Provincial Development Council social partnership mechanism does not wish away the inherent contradiction in the different interests of its constituents. In fact, beyond the different and sometimes contradictory interests of the members of the PDC social partnership mechanism is the question of awareness and knowledge around the challenges of global warming to the Western Cape region. The Western Cape region is part of a developing nation and hence

faces typical challenges of developing societies: provision of health infrastructure, educational facilities, and water; high unemployment levels, etc. These challenges are easy to understand as they relate to the daily experiences and expectations of ordinary citizens, compared to the work currently being done on climate change. The challenges of climate change are being experienced more in some parts of the region, and less in others and this relates directly to different stakeholder interests and responses on this subject.

Stakeholder approach

Section 5.3 of the Terms of Reference (TOR) to this work reads as follows:

> *Develop the Strategy and Action Plan using a thoroughly consultative process with all provincial and national stakeholders, including but not limited to, all relevant organs of state, including provincial treasury, local authorities; leading scientific institutions and individuals involved in climate change research and advice, business, industry, relevant NGOs and CBOs and civil society. The consultative process shall include, but not be limited to the PDC social partnership mechanism. The Consultative process must include significant capacity building elements to ensure that all participants are empowered to make meaningful contributions.*

The Department of Environmental Affairs and Tourism defines stakeholder engagement as a spectrum of increasing levels of engagement between stakeholders in the decision making process. These levels of engagement range as depicted in the table below, with related objectives (DEAT 2002, IEMI Series 3).

Table 14: Objectives associated with different levels of stakeholder engagement

Level of engagement	**Objective**
Inform	Provide balanced and objective information to improve understanding of issues
Consult	Obtain feedback from stakeholders on analysis or decisions
Involve	Work directly with stakeholders to ensure issues and concerns are understood
Collaborate	To partner with stakeholders on all aspects of the decision making process
Empower	Placing the decision making powers in the hands of stakeholders

Source: DEAT, 2002

These terms of reference effectively translate into employing the top four levels of stakeholder engagement with objectives as defined in the table above. The stakeholder engagement process in this work is informed by the TOR and had the following objectives (amongst others):

- To raise stakeholder awareness around the vulnerabilities of the Western Cape region to climate change impacts

- To inform stakeholders about global and regional projections on climate change
- To identify stakeholder experiences and responses to current climate change impacts, and factor these into the overall response strategy
- To solicit inputs from stakeholders into the response strategy and action plan of the Western Cape region.

In achieving the above deliverables, a range of platforms were created consistent with the participating stakeholders.

a) *Focus interviews*: Interviews sessions were held mainly to solicit specialist opinion from particular stakeholders e.g. the insurance industry. These platforms tended to ignore the challenges of climate change language and technical content as relevant specialists on the team of consultants were available to engage. This means focus interviews were largely homogeneous in the choice of stakeholders being engaged.

b) *Focus meetings*: These meetings were largely held where stakeholder numbers ranges from 1 to 30 people, information sharing and consultation being primary outcomes. These stakeholder platforms accommodated a limited variety of stakeholder interests mainly because of time and geographical considerations. For example, a WCDM local authority focus meeting had emerging farmers and smme stakeholder interests in attendance.

c) *Workshops:* Workshop platforms were created to allow space so that all levels of stakeholders could engage the subject matter and feed into the strategy development process at different stages of the process. Significantly, these platforms were open to the general public through various advertising platforms.

Stakeholder identification

The identification of stakeholders for participation in drafting the region's climate change response strategy and action plan was guided by the PDC social partnership mechanism – government, labour, business and civil society. The choice of who would participate within these four broad sectors of the stakeholder base in the region was largely decided by:

- available data in various stakeholder databases used
- specialist input considerations
- time considerations connected with delivery of the final strategy document, in particular with regard to the holiday season (months of December and January).

With regard to the profile of the stakeholders targeted for engagement in the strategy development process, the stakeholder engagement process accepted upfront the technical content of the task beforehand and the different levels of literacy and awareness of different stakeholders. To this end a conscious attempt was made to create an accommodating environment at various stakeholder engagement platforms.

Government

Stakeholders within the government sector were invited as split along provincial departmental lines. In view of the time challenges of getting all departments involved, focus was placed on getting the participation of key departments at this stage of the strategy development process. To this end, key departments like DWAF and DOA were consistently engaged throughout the strategy development process.

Labour
Labour in the Western Cape (and nationally) is mostly located under the umbrella of the Congress of South African Trade Unions (COSATU). To this end our primary drive was to secure the participation of Cosatu as they have the mandate to represent the majority of workers in the region. Cosatu is also a member of the PDC hence this drive for their participation. Note that platforms were also created for other labour formations existent in the region besides Cosatu, to inform the strategy development process. To this end formations like the National African Confederation of Trade Unions (NACTU) and the Independent Trade Union Federation (ITUF) were engaged, with varying levels of success.

Business
The choice of stakeholder participation from the business sector varied from specialist input to general input. Some sectors such as insurance and agriculture had particular specialist input to make into the strategy development process. To this end a number of engagements at various levels were arranged. Equally, business was approached through the existing regional representative platforms like the Cape Regional Chamber of Commerce, which also happens to be part of the Provincial Development Council social partnership mechanism.

Civil Society
Civil society stakeholder participation was guided largely by information in our database, including the databases of various organizations participating in the climate change dialogue. This was to ensure a wider level of participation than those already involved in climate change platforms. Beyond this, civil society was invited through various newspaper adverts and radio interviews to the workshops held in various parts of the region. These newspaper adverts and radio interviews were also intended to raise the awareness of civil society around climate change.

Analysis

Process

Stakeholder identification/invitation and participation
Of the four social partners in the PDC social partnership mechanism only civil society seemed not to base their participation on 'self interest'. 'Self interest' here refers to the deployment of resources to the stakeholder engagement process as against other government/business commitments. It was not easy to get commitment to the process from either government or business in the PDC, except for key affected departments and businesses. Notably government departments such as the Department of Environmental Affairs and Development Planning (DEA&DP), Department of Agriculture (DOA) and the Department of Water Affairs and Forestry (DWAF) participated at all levels and stages of the process.

It is notable and commendable that the South African Local Government Association (SALGA) was very consistent in the process, as it is closely linked to the implementation platforms of the strategy once finalized. It is also commendable that local municipalities were very eager to participate and carry the process forward, in spite of a serious lack of awareness and knowledge of the subject matter. Reference here is made to the West Coast District Municipality (WCDM), Cape Winelands District Municipality (CWDM), and Eden District municipalities. It is noted, regrettably that the Department of Local Government and Housing (DoLG&H) has not participated in the process, and

instead the Disaster Management Unit was also very keen to give invaluable input into the process.

Civil society as a stakeholder was largely represented by the NGOs and development agencies that participated in the process. In addition a number of citizens responded directly to the invitations to the workshops both in George and Cape Town. Broadly speaking the contribution of civil society to the strategy is acceptable, noting that women and youth as focus areas deserve more attention. Again, in appreciation of this shortcoming, attempts at employing the PDC for possible recourse were unsuccessful.

The Trust for Community Outreach and Education (TCOE) stakeholder engagement platform sought to enhance efforts to access input from the civil society groupings. Their work is significant to rural communities of the Western Cape region and their comment to this work is important.

Noting the challenges of accessing the different stakeholders within the social partnership, the level of participation and input received is sufficient to generate a robust and implementable response strategy and action plan. However, the following points should be noted:

Gaps in the stakeholder engagement process

Labour as a stakeholder was inadequately represented in the process. Only two Cosatu unions participated, namely FAWU (attended the first Kirstenbosch workshop) and NUM (held a focus interview). Attempts to engage NACTU locally were unsuccessful; and ITUF, WCAWU and GWU attended a session in Paarl. The reasons for this anomaly could be as follows:

- A serious lack of capacity within the labour movement.
- Lack of awareness/appreciation of the relationship between labour interests and climate change impacts (e.g. possible negative impacts on employment levels in the agriculture sector; opportunities in the energy sector).
- Time pressures and competing interests within the period in which this work had to be completed.
- The absence of support from the PDC. (The PDC could not facilitate the contribution of labour to this work, although labour is a member of the social partnership mechanism.)

<u>Labour has not been fully participant in the development of the Climate Change Response Strategy and Action Plan.</u>

The table below depicts some of the stakeholder engagement platforms that could not materialise for a variety of reasons. It is significant to point out that these stakeholder engagement platforms were targeted because they are significant contributors to the PDC social partnership mandate at different levels of their operations. Secondly, the terms of reference to this work makes reference to these platforms as significant contributors to shaping the development of the people and environment of the Western Cape region.

The platform with national government departments sought to address integration and alignment challenges to the Western Cape climate change project.

It is important to point out that, noting that Labour leadership was unavailable, alternative efforts to access individual member unions like NEHAWU, SATAWU, NUMSA, FAWU and SAMWU were also not successful. These efforts to secure the involvement of labour are an indication of our appreciation of the enormous <u>positive impact</u> labour can and must make on this work, hence the need to revisit the PDC social partnership mechanism to facilitate that engagement.

Table 15: Planned Meetings that did not take place

Meeting	Target Date	Reason
Provincial Development Council (PDC)	December 2006	The PDC were unable to participate
COSATU	December 2006	COSATU were unable to participate
National Government Departments	January 2007	The consultants have not engaged with national government directly, but this has been taking place through DEA&DP's participation on the National Climate Change Committee (D Laidler and D Elford). The principal suggested that a consultant presentation to the NCCC take place once the strategy is complete.
Surplus People's Project	January 2007	Relevant official was out of the country.
Trust for Community Outreach & Education	January 2007	This organisiation did not respond to attempts to make contact with them.
Atlantis Development Agency	January 2007	The current restructuring process that this organization is undergoing prevented them from participating.
SATAWU	January 2007	No response.
NUMSA	January 2007	No response.
COSATU	January 2007	No response.
Department of Local Govt. & Housing	April 2007	No response.
Department of Transport	April 2007	DoT were not available for the meeting.

Facilitation methods/aids

Stakeholder engagement was facilitated via interviews, focus meetings, workshops, print and electronic media.

- For interviews and workshops, presentations were made by the consulting team, and clarity and inputs were solicited from stakeholders. The general finding in most engagements is that familiarity with the subject matter improved the levels of participation both qualitatively and quantitatively. Focus meetings and workshops were particularly effective for all stakeholders as the space for dialogue was open and non-threatening. Specialist interviews were very effective for stakeholders with particular technical/specialist inputs into the process, as these platforms afforded them the opportunity to express themselves freely without consideration for technical language (as would be the case in a workshop setting). The language of climate change was consistently noted for its lack of simplicity in focus meetings and workshops.
- Radio interviews in the local radio stations seemed to touch predominantly the stakeholders in the dialogue platform. The use of radio as a medium for stakeholder engagement was not engaged fully as more localized community specific stations were not engaged due to capacity and resource constraints.

Time as a critical variable

This consideration emanates from the appreciation of the business cycle within which we operate. The business community, labour and government become unavailable for engagement from early December to the middle of January, and all three layers of the PDC social mechanism come back in January with stresses from outstanding challenges from December. This means that a six month project becomes a four month project. This creates an extraordinary amount of stress on systems already stretched to their limits relative to capacity challenges. It is highly probable that the responses of some stakeholders would have differed considerably if the timing had been different.

Content
With regard to language, the point has already been made that the language of climate change is not easy to comprehend. The context of this submission is from stakeholders who wish to facilitate dialogue beyond their stations, those who occupy positions that allow for further dissemination of information on the vulnerabilities of the region and the Western Cape Climate Change Response Strategy and Action Plan. It is significant to point out that beside similar comments from other stakeholder groups, the significance of language was echoed by SALGA and professionals involved in Integrated Development Plans / Provincial Growth and Development Strategies from WCDM, CWDM and Eden district municipal authorities.

Stakeholder profiles – The separation of specialist input from general inputs was appropriate and effective. The availability of specialist input in some general platforms (focus meetings/workshops) also provided more clarity and depth, without compromising the non threatening flavor of such platforms. A majority of stakeholders participating were literate and could engage in the common language of the sessions (English/Afrikaans).

Subject content – Noting the earlier comment on language of climate change, the stakeholders engaged could participate in the sessions. Stakeholders participated fundamentally to seek information, clarity and give input. Stakeholders who sought clarity were mostly new to the climate change dialogue, and these would benefit greatly from processes that seek to support new awareness/knowledge gained (beyond the life of this work). Current practitioners support the need to simplify the language and content of climate change to increase awareness.

Recommendation
The language of climate change is technical, highly specific, and unfamiliar to the majority of the general population. It is strongly recommended that the communications around climate change be packaged in clear and understandable formats so as to be accessible to the widest range of people. This forms the basis of developing a communications platform and education and awareness campaigns that are accessible to all. The communications strategy attempts to address the issue of simplifying the language of climate change.

Support

> *''Social Dialogue is construed as the basis for the construction of developmental partnerships in the most recent history of the Western Cape of South Africa. … The status of social dialogue in the province can therefore, to an extent, be assessed through an examination of key issues identified and the responsiveness of the social partners to the pursuit of the Strategic and Key Measurable Objectives set".*

This introductory statement to the PDC annual report of 2005/2006, read in the context of this climate change project, elevates the challenges around the responsiveness of social partners to the task at hand. Elsewhere in the same report *reference is made to the adoption* of the Guidelines and Code of Ethics assisting to resolve the establishment of clearer rules of engagement.

The PDC social partnership mechanism remains a very critical vehicle to harness the momentum generated for the climate change project through different stakeholder engagement platforms. It is therefore significant that engagement rules with the PDC mechanism are clear and effective, so that even when the system is pressurized through time or capacity constraints there are known alternative processes that protect the continuity of social dialogue.

Conclusions and recommendations

Stakeholder platforms

It is suggested that further efforts are employed to engage the youth and women structures on the potential impacts of climate change and the region's responses thereto. A byproduct of such effort is the envisaged positive changes in behavior subsequent to raising awareness levels via the engagement process.

It is also recommended that further effort be employed to engage Cosatu, in spite of their lack of commitment to this process to date. It is significant that they represent an important number of the very people whose behavior changes are the subject of this work.

The experiences emanating from the stakeholder engagement process in this work suggest a need to review the relationships around the PDC social partnership mechanism:

- The PDC social partnership mechanism seems to have capacity challenges that limit its ability to assist the stakeholder engagement processes within the social partnership mechanism, probably due to its design.

- In strengthening the PDC mechanism, it would help if capacity is also added to facilitate **ward level engagements** as an area of special focus. The Constitution of our land was written at this level, and it is only fitting that high impact challenges like climate change receive input and impact on awareness and education at this level.

Ward level engagements

There is a layer of civil society that can and should be accessed in all major impact works – via the ward councilors. This point is particularly relevant as it talks directly to the desire to positively change the behavior of all the people in the Western Cape region. This report is submitted before the test stakeholder engagement pilot at ward level takes place with a councilor in Mitchell's Plain. The commitment publicly declared in the meeting of 28 February by the councilor in question and related dialogue thereafter forms a sufficient basis for optimism that this platform can enhance social dialogue.

Awareness and education

Marginalised communities need extensive awareness campaigns around climate change if the desired changes in behavior are to materialize.

- Some awareness campaigns can translate into economic activity for these communities, e.g. training around fire prevention challenges should be a deliberately localised activity. Capacity can and should be built within these communities to generate the centre around which behavior changes are sustained. It is an anomaly that buildings in central Cape Town have fire drills by law, whereas fire prone communities depend on external inputs for their responses to such fires!
- It is significant that government, business and labour be sensitized to their responsibilities in ensuring the effectiveness of the integration of effort around climate change. The lack of urgency in some of the sectors can be attributed to lack of awareness/education on the subject matter. This might also include the inability to contextualise various sector contributions or impacts in the PDC social partnership mechanism.

Research Methodology

Methodology and Approach

The approach in developing a climate change response strategy and action plan for the Western Cape was aimed at establishing parameters for action for dealing with climate change impacts using a 3-step process of analysis under the following broad themes: ***situation, complication*** *and* ***resolution****.* This analysis required an interdisciplinary approach that resulted in the drawing in of experts from the natural and physical sciences to constitute the project team.

Phase I

The situation was concerned with project scoping and design involving desktop research of studies representing best practice approaches in the design of strategies and action plans to deal with climate change in regions of the world that have climate conditions similar to the Western Cape. The interdisciplinary review process involved experts from the following fields: sociology and economics; biodiversity; water; coastal and marine; agriculture; tourism; fisheries; energy; transport; air quality and health; infrastructure and built environment; livelihoods and disasters. The activities that were undertaken at this stage included a review of all relevant local and international literature[78] on strategies, incentives, financing models, implementation models and actual case studies in relation to climate change response. These studies were at both the country and regional levels. ***The situation*** phase of the assignment was also concerned with the identification of all key stakeholders (local, provincial, national and international). Stakeholders from government, civil society, communities and financiers of the strategy were also identified. Key stakeholder and public communication themes for the response strategy were assessed. This segment of the work also used the ***PESTLE***[79]*(see Appendix 1)* and ***DPSIR***[80]frameworks as analytical tools in examining the driving forces of climate change in the province, among others.

Phase II

The second step of the process, **complication,** was associated with a comprehensive assessment of the range of possible mitigation and adaptation strategies. With the aid of best practise vulnerability assessment and prioritisation benchmarks, a set of options was selected to feed into the strategy development. Biophysical (Climate science) modelling provided the varying climate change impacts that informed the risk and vulnerability assessment on the various sectors of the economy in the province. The modelling effort used the median responses from seven Global Climate Model (GCM) projections. Global Climate Modelling uses computer models to extrapolate from current data to create projections into the future. Using data about the present-day climate, the projections were made for the period 2045-2064. This information was linearly scaled to 2035 as a projection for the 2030s. The median was rather used because of the argument that if a particular model happened to be an outlier, the arithmetic mean could distort the results.

[78] See Appendix 4 for a list of the resources consulted as part of this exercise.
[79] Political, Economic, Social, Technological, legal and environmental (PESTLE). See Appendix 1.
[80] Driving forces, Pressures, State, Impact and Response (DPSIR)

Linear scaling is simply using the values for the present climate with the values for the 2045-2064 period, and assuming a constant rate of change between now and then, estimating the values for the 2030 - 2040 period. For example, if average temperature for the current climate was, say, 20 deg C, and for 2045-2064 was 22 deg C, then for during the 2030s the linearly scaled temperature would be around 21.5 deg C.

Based on the output of the climate science component of the assignment, subject specialists examined the impact on the natural and physical systems of the Western Cape. Specialist areas were in biodiversity; water resource management; Coastal and marine science; Agriculture; Tourism; Fisheries; Energy; Transport; Air quality and health; Infrastructure; Built environment; Livelihoods and disasters. The natural system impact assessment also included an examination of the effects climate change on the livelihoods of vulnerable groups in the province.

Phase III

The third and final phase was concerned with evaluating and costing the prioritised response options, which formed the basis for the climate change response action plan. Criteria adopted after expert identification and consultation with stakeholders in the multi criteria-analysis model were:

- ***Cost effective analysis***
- ***Ease of implementation***
- ***Neutral to positive social and livelihoods impacts***
- ***Environmental effectiveness***

The legal aspect of this leg of the project was concerned with a review of the existing environmental legislative framework and assessing the gaps and capacity required for implementation of the strategy and action plan.

The thrust of the communications strategy assessment was to identify and engage with stakeholders, identify key target audiences, current perceptions of Western Cape climate issues and the appropriate communication tools to use in the implementation of the strategy and action plan.

Expert opinion, team workshops, focus group meetings with broader expert teams and stakeholder review all contributed to the effective application of the multi-criteria analysis model.

Identifying the solution

Stakeholder Engagement

The stakeholder engagement exercise which continued throughout the life of the project cut across all phases of the project implementation as it offered a platform for communicating outcomes and a forum for feedback on output across all the specialist areas covered in the project consortium. The Stakeholder engagement effort drew on the four principles of *consultation*, *involvement*, *collaboration* and *empowerment*. However, the specific instruments used in attaining the objectives

of the stakeholder analyses were focus interviews to solicit specialist opinion on selected issues such as those dealing with managing climate change risk. Then there were focus meetings, which had participants varying in number between 2 and 30 at a time. The last mechanism used in the stakeholder engagement were workshops. The stakeholder engagements created a forum for all levels of stakeholders including subject matter specialists from both the consortium and the public as well as 'lay people' to engage on various issues of importance to the assignment in an open and frank manner. The special focus groups that constituted the stakeholder groups were people from Government, labour, business and civil society.

Strategy and action plan review

The strategy has been taken through a review process with the different provincial government departments. This has entailed a process of presenting the response strategy and the actions relevant to the audience in the department and discussing and reviewing the content. Particular emphasis was given to establishing existing programmes and priorities (ensuring that the proposed actions do not result in duplication) and understanding accountability, budget constraints and identifying action custodians. The broad objective of these departmental review processes was to establish acceptance levels of the proposed strategy and to identify any gaps. The process also served to inform, educate and create/raise awareness levels of the impacts and risks that climate change present to the province.

Research

Desktop research underpinned the analysis and solution identification work. A wide range of literature was reviewed, including responses to climate change, action plans and strategies of other countries and regions. Approaches to developing response strategies and adaptation and mitigation strategies were also researched and suitable models identified to inform the development of the Western Cape Strategy and Action Plan.

Critical to progressing the research (desktop, biophysical and socio-economic) was the development of key research questions that should underpin a response strategy and action plan.

The following questions / research items informed the development of the biophysical analysis:

Climate Change scenarios (High and Low) for the identified regions in the Western Cape as an initial assessment of risk for 2030 to 2050: (In other words, we are looking for 2 scenarios for each time horizon)
Temperature
Rainfall
Sea levels
Wind
Increases in extreme weather events
Disasters - fires - frequency
Potential evaporation
Solar radiation - for example, it would be useful to know where PV systems are best placed
carbon dioxide concentration
Can these scenarios estimate the change (in, say, temperature) and be tempered with an approximation on the degree of uncertainty within that estimation?

To what time period or date would these scenarios be relative? i.e. 2030 relative to 1990 or today's date? - i.e. what is the baseline? The literature reviewed uses 1990 as the baseline.
Could the scenarios go so far as to assess impacts, risk and vulnerabilities? So, for example, a decline in annual rainfall with higher evaporative demand would lead to a tendency for less run-off into rivers. Droughts are likely to become more frequent and severe with greater fire risk.
Correlation between trends and scenarios? What methodology do/would you use to develop these scenarios? If trends inform scenarios in your methodology, could we make the trends explicit in some instances and/or look at trends as well?

Certain issues for discussion were identified early on in the process. These were drawn from the areas of uncertainty in the list of research questions selected for development of the strategy. Identification of these issues was also informed by best practice approaches to adaptation studies as given in the Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies prepared by UNEP[81].

1. What time? And what space?
What is the spatial extent to be considered for designing the adaptation strategy and action plan?

2. What assessment boundaries ought to be considered?
What are the priority sectors and regions in Western Cape in relation to vulnerability to climate change effects?

3. What assumptions should underlie proposed Adaptation Strategy and Action Plans?

a. Are we going to assume that past behaviour will continue into the future because of ignorance about climate change effect? OR
b. Will the population know precisely what to do to adapt sufficiently?

4. What plans should be made for communication and use of study results?
The specific issues were:

a. What output will be most useful to Western Cape government?
b. How will the study results feed into policy and decision-making processes?
c. How is the study output going to feed into the policy decision making process?
d. How are study results going to be communicated to a wider population in Western Cape?
e. How will study recommendations relate to Western Cape economic and social development strategy?

5. What research approach should be adopted for present study?
Some of the alternatives available in the literature are as follows:

a. Quantitative
b. Biophysical
c. Economic models

[81] UNEP (1998), Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies, Version 2, editors, Fenestra, J.F., I. Burton, J. B. Smith and R.S.J. Tol, United Nations Environment Programme, Kenya and the Institute for Environmental Studies, Amsterdam.

d. Integrated systems
e. Expert stakeholder judgment and participation
f. Remote sensing and GIS.

6. How do we keep on track and assess progress on implementation of adaptation strategies and action plans?

Some of the research questions that underpinned this work were:

- What are the gaps in the Status Quo report in relation to present assignment – e.g. key research such as agriculture?
- What are the vulnerability criteria and /or assessment methodologies used in the available literature?
- What are the determinants of vulnerability?
- What are the vulnerability criteria appropriate to the Western Cape and a response strategy? For example:

Exposure
Sensitivity
Adaptive capacity
Adverse implications
Potential benefit
What are the contributions (GDP) of the various sectors and regions of the Western Cape in relation to vulnerability to climate change impacts?
What are the priority sectors and regions in Western Cape in relation to vulnerability and climate change impacts?
What are the climate pressures on industry sectors that have been prioritised? i.e.:
- Agriculture
- Fisheries
- Tourism

What are the climate pressures on the natural environment? Specifically:

- Water
- Drought
- Biodiversity and fires
- Coastal zones
- Storms, floods

What are the climate pressures on health and infrastructure?

- Health
- Energy

What are the climate pressures on livelihoods?
What are the key climate variables when considering the above?
What are the best practice adaptation strategies (i.e. from the literature) in the areas of concern?
What are the most appropriate adaptation strategies for the Western Cape?

What are the costs involved in implementing suggested adaptation strategies?
Which are the most cost-effective and economically efficient? Are they market-based mechanisms?

Are these options explicitly about climate change or do they have other benefits / advantages?
How important is climate change as a factor when considering these options?
What is the lifetime of the options proposed?
Which climate variables are likely to be the most important when considering these options?(i.e. climate change scenarios)
What are the criteria for recognising a successful outcome?
What are the legislative requirements / constraints?

Who are the key stakeholders in climate change-related matters (as defined) in the Western Cape?
What is the most appropriate stakeholder engagement and Public Participation strategy for the project?

What public communication theme should be used for the response strategy?

A directory of the literature reviewed is contained in Appendix 4 hereto.

Multi-criteria analysis and tools

Pieterson (2006) states that *the general objective of MCDA is to assist a decision-maker or a group of decision-makers to choose the best alternative from a range of alternatives in an environment of conflicting and competing criteria.*

When making decisions on responding to climate change, it is essential to be clear on the criteria and tools that will be used to reach a constructive outcome. Such criteria can be conceptually grouped as economic efficiency, social equity, ecological sustainability and institutional capability, but can be refined further to give consideration to timing, spatial implications and the specific values of interest groups in multiple dimensions. The choice of criteria and the weighting between criteria will depend on each country or region's short and longer-term development goals (Jepma & Munasinghe 1998:145; Vaillancourt & Waubb 2004). Apart from MCDA, some of the other most frequently-used evaluation tools include cost-benefit analysis (CBA), cost-effective analysis (CEA), decision analysis as well as integrated assessment frameworks and models.

When there are multiple (often conflicting) objectives, and when public participation is prominent (see Joubert *et al* 1997), a multi-criteria decision analysis (MCDA) may be used. It is a process whereby the evaluation of trade-offs among competing objectives such as costs, ecological effectiveness and social consequences are formalized.

A well-designed MCDA forces a decision-maker to make trade-offs between conflicting objectives. In the context of this study on climate change response actions, it suggests that the costs of responding are quantified, that social and environmental consequence of the response is clearly ranked and that institutional capability to implement the response is articulated well. MCDA, like any other static evaluation tool, does not deal effectively with uncertainty and is highly dependent on the quality of information used in the analysis, the selection of objectives and the weighing of options. With these limitations in mind, it can still be very useful to present trade-offs between objectives to the decision maker in a simple and user-friendly way.

Part 4

Challenges, conclusions and recommendations

Toward implementation: Challenges, conclusions and recommendations

The outcomes-based Climate Response Strategy and Action Plan highlights a number of key actions required to achieve the desired outcomes. Many of these are action items that either already are, or should be happening in any case. In these instances, climate change simply exacerbates an already challenging situation and adds urgency to the timelines of the necessary response. Table 17 (at the end of this section) provides a summary of the action plans contained in each of the four outcomes-based programmes in the response strategy and action plan. It further reflects areas of existing and / or planned activities that are related to the identified action (where known to the authors at the time of submission of this report). Many of the goals and objectives embodied in the action plan link into other major Western Cape government-driven initiatives such as:

- The Sustainable Development Implementation Plan
- The Integrated Energy Strategy
- The Provincial Spatial Development Framework
- The Provincial Growth and Development Strategy.

There are also links with existing effective initiatives such as the Working for Water Programme, the Working for Wetlands Programme and Working for Fire. These and other programmes all provide excellent platforms for implementing aspects of the response strategy.

Whilst all these platforms and initiatives are a good departure point for beginning implementation, the missing component for effective implementation of the entire strategy is cross-cutting institutional arrangements and capacity.

The proposed Provincial Climate Change Committee (PCCC) if effectively constituted should provide a platform for the cross-sectoral coordination and strategic direction that is needed to implement the strategic goals and integrated responses to climate change that are embodied in the Western Cape Climate Change Strategy and Action Plan.

Table 16: Key results and outcomes of the Climate Response Strategy and Action Plan

Results (Potential to benefit and reduce/minimise losses due to Climate Change)	**OUTCOMES**
▪ Sustainable development goals are achieved ▪ Climate change impacts are reduced ▪ Potential benefits are reaped ▪ Potential losses are minimised or avoided ▪ Education and awareness of the general public, leading to autonomous adaptive behaviours.	**ADAPTING TO CLIMATE CHANGE IMPACTS** **MINIMISING CLIMATE CHANGE LOSSES** **MAXIMISING POTENTIAL TO BENEFIT** **INCREASING RESILIENCE**

Source: OneWorld Sustainable Investments, 2007

***Recommendation**: Developing this Response Strategy and Action Plan has given the process of responding to climate change in the Western Cape increased momentum and has significantly increased public awareness and knowledge of climate change. It is important that this momentum is not lost, and that the PCCC be constituted - with the results and outcomes that appear in Table 16 providing the basis for the development of a Terms of Reference for the committee.*

Monitoring and Review

The outputs of all climate change response actions in the process of managing the risks of climate change must be kept under review so that, as circumstances change and new information emerges, plans can be maintained and kept up to date.

The Climate Change Response Strategy and Action Plan is dynamic and requires regular updating and validation to maintain a cutting edge. The results of ongoing monitoring and evaluation of the impacts of implemented measures and strategies should be used to inform this validation. Monitoring needs to happen on two distinct levels:

- Monitoring the rate and extent of climate change against projections (the latter will become more refined and of a higher resolution as focused local research on climate change progresses)
- Monitoring the provincial progress in adapting to these changes, managing the risks of climate impacts and reducing vulnerability

Important aspects of the monitoring and review process include:

- Keeping the analysis and review up-to-date, including developing and updating climate change scenarios and incorporating new information about climate change impacts.
- Reviewing the province's progress on the actions that flow from the implementation process, reporting on this progress and using the progress evaluation to re-inform the strategy. This may mean implementing new or treatment actions to reduce risks and / or undertaking further more detailed analysis (focused climate change research).
- Ensuring that the actions are implemented timeously and cost effectively. These must be documented and reported on to relevant stakeholders with feedback re-informing the dynamic response strategy and action plan.
- Reviewing the criteria for evaluating response options and measures periodically (every 5 years) to ensure currency and relevance. These need to be reviewed against the provincial Sustainable Development Implementation Programme and the goals contained therein.
- Establishing a framework (within the PCCC) for reporting on climate change progress, review and implementation processes – in other words: publicly track the Western Cape's progress on climate change and climate change response.
- Establishing platforms for regular stakeholder and public communications on climate change, progress and challenges.

Recommendation
Maintaining a sound information database that is regularly updated and expanded is a critical success factor to constructive ongoing monitoring and review. Both are in turn critical success factors in keeping the province's response to climate change dynamic, relevant and informed.

Conclusion

The analysis, research and review work conducted in the 2005 Status Quo Review and in 2006 / 2007 in developing this response strategy and action plan points clearly to the need for a response strategy that mitigates risk, reduces vulnerability and strengthens the province's capacity to adapt to climate change – and at the same time reduces the provincial carbon footprint.

A number of challenges exist when considering the implementation of a climate change response strategy and action plan for the province. A significant challenge lies in the examination of appropriate and facilitative ***institutional arrangements*** required for effective implementation. Climate change is cross-sectoral by nature and is not restrained in any way by human-imposed constraints such as linear government functions. A cohesive water programme, for example, requires provincial ownership, Department of Water Affairs and Forestry (DWAF) ownership and participation and then significant involvement by other departments such as Agriculture. DWAF does not, however, have a provincial function and, although there are structures in place such as the Provincial Water Liaison Committee, accountability is not altogether clearly established.

A number of the conclusions are inherent in the response strategy and action plan. However, the province and South Africa will need to give careful consideration as to how the institutional arrangements are best structured to allow for the realization of sustainable development goals while dealing with the negative and positive impacts of climate change on achieving these. Both climate change and sustainable development – which are indeed intertwined – give rise to contemplation of the problems of inequality and poverty. When considering these against the environmental challenge inherent in the climate change scenario, it may seem as if the latter is less important. But, to quote Nobel economics laureate and philosopher Amartya Sen, who recently visited South Africa to deliver a lecture on poverty, war and peace, "***It seems (to me) that the main challenge for a human being is how to take note of each of these major issues without putting them in a horse race with each other"***[82]***.***

[82] Quoted in the Sunday Independent, 29 April 2007.

Table 17: Integrated Climate Change Response Strategy and Action Plan for the Western Cape

Integrated Climate Change Response Strategy and Action Plan for the Western Cape

***Key outcome # 1*: Establish a cohesive Water Supply and Infrastructure Management Programme that integrates climate impacts and risks**		
Action:	**Responsibility**	**Existing initiatives / platforms**
• Establish a Water Group and co-ordinator at a provincial level and a Programme Steering Committee (PSC) that is representative of DWAF, DoA, the Disaster Management Unit, Local Authorities, communities and industry	**DWAF** as lead, with DEA&DP and CapeNature; DoA. The existing Provincial Liaison Committee, run by DWAF can be given this mandate	Provincial Water Resource Group
• Establish a cohesive and integrated vision and targets for water management at a provincial level and develop related Terms of Reference	Co-ordinator, with the PSC	The Premier's office is finalising an integrated water management plan for the province with DWAF and other stakeholders
• Build capacity in the relevant CMAs	DWAF	2 CMAs are established – could act as pilots / centres of excellence for establishing capacity in the balance
• Develop a research and planning manual	DWAF	
• Map out municipal water supply systems, with storages and linkages and drawdowns • Map out irrigated agriculture, with crops and water supply systems (off and on-farm) • Develop financial model of irrigated agriculture • Develop drought scenarios • Model impacts of droughts and timing and costs of back-up response options such as desalination, wastewater treatment and the use of the aquifer.	Co-ordinator with relevant departments	
• Research and verify extent of losses	Consultants	Cape Town City and DWAF have existing research and CTC has implementation plans (not yet implemented)
• Set targets – e.g. reduce water leaks and UAW to 15% by 2010. Monitor and validate this through research in order to quantify water savings in context of new supply systems.	DWAF / Premier's office	
• Allocate responsibility and create accountability [83]	DWAF / Premier's office	
• Secure appropriate budget	DWAF / Treasury	
• Communicate the programme and outcomes	DWAF Communications department /	

[83] DWAF does not have a provincial function. The Premier's office is drafting an integrated water plan for the Western Cape with DWAF input.

	PCCC / Premier's office	
• Monitor effectiveness	DWAF / PCCC	
• Establish and communicate water efficiency targets – 15% by 2014	DWAF	
• Establish an appropriate pricing strategy / tariff structure	DWAF / Treasury	
• Establish a fund into which the environmental tariff should flow – a Western Cape Fund	DWAF / Treasury	
• Appoint a fund manager and establish criteria for fund disbursements – for example, research into capacity for water supply back-up and establish whether or not this back up supply could come from a desalination plant	DWAF / Treasury	
• Communication, education and awareness	DWAF communications department and PCCC	
• Establish clear monitoring platform – of water efficiency levels in all sectors and fund management	PCCC	
• Create a science-government platform for discussion and formulation of needs for water-related requirements (e.g. research requirements; information database; awareness campaigns)	Co-ordinator / PCCC	

Key outcome #2: **Establish a focused climate change research and weather information programme**		
Action:	**Responsibility**	**Existing initiatives / platforms**
▪ Allocate the budget on the basis of 14 stations for the 2007/2008 financial year and 11 for the 2008/2009 financial year	Department of Agriculture (DoA) and Treasury	Many weather stations exist but are not consistent and do not yield same resolution of information. Some are privately owned and monitored
▪ Establish the channels for communicating weather information	DoA communications department with the PCCC; Provincial Disaster Management Unit and Local Authority Emergency Services	SAWS
▪ Establish the platforms for collating weather data and analysis thereof in the context of climate change indicators	DoA / PCCC / CSAG? (to be determined)	CSAG and SAWS do some weather monitoring – could act a a platform for expansion
▪ Allocate budget for targeted climate change research and modelling and reporting for the province	DEADP / PCCC / CSAG	

Key outcome # 3: Establish clear linkages between land stewardship, livelihoods and the economy

3.1 Land Care and Resource Conservation

3.1.1 Climate Change and Wetland Conservation

Action:	Responsibility	Existing initiatives / platforms
▪ Determine and implement the Ecological Reserve for key wetlands	DWAF	Working for Wetlands programmes
▪ Institute efficient demand-side management, especially in the agricultural sector	DA, DWAF	
▪ Integration of land and water resource management in order to reduce non-climate stresses on wetlands	DWAF, DA, DEADP	Working for Wetlands
▪ Assessment and expansion of the protected area system to accommodate valuable but threatened wetlands	Working for Wetlands, CAPE, CapeNature, DEADP, SANParks	Working for Wetlands
▪ Assessment of climate change-induced threats to wetland-based livelihoods (e.g. harvesting of waterblommetjies and restios and fisheries) and development of strategies to mitigate and adapt to these impacts	DEAT/SANBI? (to be determined)	
▪ Assessment of the actual vulnerability of wetlands and wetland species and functions to climate change and sea-level rise	DEAT/SANBI? (to be determined)	
▪ High priority management actions, including rehabilitation, in valuable wetlands that are likely to be lost or degraded	CapeNature, DA, DWAF, Working for Wetlands	Working for Wetlands
▪ Reduce nutrient loading in rivers and protect/augment riparian vegetation to offset eutrophication effects of higher water temperatures	DWAF, DA	
▪ Secure and rehabilitate wetlands that have potential to play key flood attenuation roles. Rehabilitate river channels to improve their ability to withstand and attenuate extreme flow events	DWAF, Working for Wetlands, Working for Water, DA	
▪ Re-evaluate design criteria of dams, levees and other infrastructure for flood protection	DWAF, municipalities	

3.1.2 Invasive Alien Species (IAS) Management

Action:	Responsibility	Existing initiatives / platforms
• Establish an Alien Species Management Working Group & Co-ordinator and establish a Programme Steering Committee (representative of relevant stakeholders, including community representation)	CapeNature as lead with DEA&DP, Department of Agriculture, Department of Health, DWAF (Project Steering Committee)	Working for Water (KZN model could be considered for replication to some extent)
• Develop clear Terms of Reference and a clear vision and targets in priority areas	CapeNature	
• Consolidate current programmes	CapeNature with PSC	Working for Water
• Develop provincial and regional strategic plans	CapeNature	Working for Water
• Employ dedicated Area and Project Managers	CapeNature	
• Develop appropriate IAS policies	CapeNature with PSC	
▪ Establish public private and community partnerships (for example, between Department of Agriculture and farmers (through the industry associations) on pest management programmes	CapeNature / PSC / Appropriate department and industry and community associations	
• Establish monitoring platform	CapeNature with PSC	
• Establish clear communication channels and channels for disseminating information	CapeNature; Provincial Climate Change Committee (PCCC) and DEA&DP communications	Working for Water
• Communication, Education and Awareness campaign	DEA&DP communications	

3.1.3 Extension of protected areas

Action:	Responsibility	Existing initiatives / platforms
• Allocate required funds to convert identified public and private land at risk to protected areas	DEA&DP / Treasury	
• And / alternatively engage private land owners in conservation activities through facilitative actions (Stewardship & LandCare programmes) accessing funds from the Adaptation Fund	DEA&DP (CAPE) / SANBI	
• Identify research needed to be conducted to access Adaptation Funding (including identifying suitable land)	DEA&DP / SANBI	
• Conduct research and apply for Adaptation Funding	CAPE / SANBI? (to be determined)	
• Convert 6200 ha public land by 2012 and place under management	CAPE	
• Monitor private land conversion	CAPE	

3.1.4 Fire risk management and control

Action:	Responsibility	Existing initiatives / platforms
▪ Identify key improvement and performance areas in Fire Protection Organisations and Services	DWAF / Cape / Disaster Management Unit and Local Authorities	
▪ Introduce municipal level risk rating and damage cost reduction targets	DWAF / Office of the Premier	
▪ Budget for improved capacity – resources and equipment and implement	DWAF / Disaster Management Unit / Treasury	
▪ Budget for improved Working for Fire communication, education and awareness campaigns	DWAF / Treasury	
▪ Introduce spot fines for human activity that can lead to fires (e.g. throwing lighted cigarette butts, making fires in prohibited areas)	DWAF / Office of the Premier (to be determined)	
▪ Strengthen conservation guard control capacity and manpower	DWAF / CAPE (TBD)	
▪ Implement communication and awareness campaign	DWAF communications department / Working for Fire	

3.2 Climate Change and Development Planning – the Built Environment

3.2.1 Integrate climate change into development planning and approval processes

Action:	Responsibility	Existing initiatives / platforms
Integrate Climate Change into IDPs: • Develop guidelines for integrating climate risks into IDP processes – manual • Identify 2-3 pilot municipalities to test these guidelines and run a pilot • Re-inform the guidelines and appoint a task team to support municipalities in the process of developing their IDPs with reference to climate change • Establish guidelines for IDP reviewers to assess adequate integration of climate risks into IDPs under review	DPLG with support from DEA&DP	Disaster Management have just completed manuals for IDP managers to integrate disaster Management and emergency planning into IDPs
Integrate climate risks into EIA processes • Formulate guidelines and a manual that facilitates project approvers to consider climate risks in their approval processes. • Establish accountability	DEA&DP	

3.2.2 Map the 1:50 year floodline: assess risk and infrastructure vulnerability

Map the 1:50 year floodline and disseminate information to local authorities and developers as well as to EIA reviewers to ensure responsible development planning and decision making: • Populate municipal infrastructure database for study area (if not already done) • Apply 1:50 and 1:25 year floods zones to infrastructure displays (where available) • Record entities at risk + values of replacement (including lives and livelihoods where possible) • Ground-truth for possible failure of infrastructure – e.g. undersized culverts, inappropriately placed infrastructure.	DWAF, in conjunction with DEA&DP, DPLG and The Office of the Premier	
3.2.3 Incorporate climate risks in fisheries planning		
Research and plan integration of climate risks into Operation Management Procedures in fisheries • Climate change poses a risk to fishing stocks that are already depleted by exploitation and this needs to be managed in a systematic way.	MCM in consultation with DEA&DP	
3.3 Livelihoods		
Action:	**Responsibility**	**Existing initiatives / platforms**
3.3.1 Develop socio-economic scenarios using social services data (as stated)		
• Research socio-economic impacts on communities and livelihoods affected in the fishing industry • Research the implications of growing populations on water and energy as scarce resources	DEA&DP	
3.3.2 Research the implications of climate change on fishing stocks		
• Conduct climate change specific research on fishing stocks and understand the impacts over and above existing stock exploitation issues	MCM, coordinated by DEA&DP	
3.3.3 Research impacts of climate change on tourism demand and projected growth		
▪ Research impacts of climate change on tourism demand and projected growth; understand the impacts of international mitigation on WC tourism (e.g carbon taxes on flights); Consider flight schedule issues	National DEAT, co-funded by WC Department of Economic Development and Tourism	

Key outcome # 4: Reduce our carbon footprint		
Action:	**Responsibility**	**Existing initiatives / platforms**
4.1 Air Quality Monitoring		
▪ Verify locations	DEA&DP with Local authorities	DEA&DP have already purchased 3 additional stations and are considering placement
▪ Allocate budget for stations and for education and awareness and response / early warning systems	Local authorities / Treasury	
▪ Establish monitoring human resource capacity and train	Local authorities	
▪ Establish clear channels for disseminating monitored data (with reference to the AQ Management Act	PCCC / AQ Committee	
▪ Establish early warning mechanism and system with the Provincial Disaster Management Unit structures (local authorities) and the Department of Health	PDMU / Local authorities / Dept Health	
▪ Establish communication channels with the Office of the Premier – for example to communicate high pollution events and to inform the public	PCCC / Office of the Premier	
▪ Establish guidelines for the public during high pollution events that aim to reduce / minimise the impact	AQ Management committee	
▪ Educate and communicate	Local authorities? (to be determined)	
4.2 Household fuel replacement		
▪ Extend the existing subsidy for ceilings in new houses to retro-fitting of existing houses	Housing	Kuyaso as a pilot
▪ Establish subsidies for alternate fuels (gelfuel / LPG) and related equipment (Stoves, heaters)	Housing / Treasury	
▪ Monitor the impacts of revised safety standards as developed by the paraffin industry on fire incidents and losses induced by fires	DEA&DP / DMU / Health	
▪ Establish distribution networks in the high density areas (peri-urban and rural)	Housing	
▪ Establish a communication	PCCC and Housing	

education and awareness programme (communications strategy)	communications department with Office of the Premier? (to be determined); Disaster Management Unit (under the fire brigade unit)	
▪ Establish monitoring platform	DEA&DP	
4.3 Climate change and integrated public transport planning		
▪ Research subsidy structure ▪ Research alternate fuels – viability – CNG or LPG or biofuels	Department of Transport; CTC and in context of the George Mobility Strategy (Eden Municipality	
▪ Incentivise Taxi industry / Golden Arrow to use CNG / LPG / Biofuels	DoT / Treasury	
▪ Allocate budget	DoT / Treasury	
▪ Convert 30% of provincial vehicles to CNG/LPG /Biofuels by 2010 ▪ Integrate programme into provincial initiatives such as the George Mobility Strategy and the Worldcup 2010 Transport strategy	DoT DoT / Ninham Shand / Actios	
▪ Communication education and awareness	DoT communications department / PCCC	
▪ Monitor impacts	DoT / PCCC	

4.4 Strengthen Western Cape renewable energy supply		
• Integrate with WC Integrated Energy Strategy Targets	DEA&DP / DME	
• Research and develop an appropriate pricing strategies	DEA&DP / Treasury	
• Establish a capacity building and support programme for the EE and RE supply industries – for example the installation capacity of Solar Water Heaters	DEA&DP	
• Finalise the proposed CTC by-law on SWH	CT City / DEA&DP	
• Commercialise the SWH industry with government support	Economic Development and Tourism	
• Establish a fund for financing domestic sector SWH installations and capital expenditure	DEA&DP – in partnership with Banks and the Insurance Industry	
• Implement the Solar 500 programme and ensure effective monitoring of results	DEA&DP / CEF	
• Communicate energy savings potential to domestic and	DEA&DP communications	

commercial consumers	department	
• Establish energy efficient standards for the housing development industry	Department of Housing; Local Authorities; DEA&DP	
• Establish a clear communications, education and awareness campaign aimed at behaviour change in consumer patterns	PCCC; DEA&DP communications	
•		

4.4 Waste Management and Climate Change

Action	Responsibility	Existing initiatives/ platforms
Opportunity assessment and analysis of all waste streams and provincial MSW sites and practices – including recycling opportunities and an analysis of job creation potential	Local Government and housing and PCCC / DEA&DP	
Investigation of R&D opportunities and allocation of R&D budget	Department of Economic Development; DEA&DP; Treasury	
Assessment of policy, possible incentives, appropriate processes to achieve integrated waste management	Department of local government; DEA&DP	
Development of a clear waste management solution and action plan for implementation	DEA&DP; Department of local government	

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Glossary of terms

Adaptation	Adjustment in natural or human systems to a new or changing environment. Adaptation to climate change refers to adjustment in natural or human systems in response to climate stimuli and is instituted to moderate the effects of climate change. Adaptation response depends on land use.
Anthropogenic	Human made. Usually used in the context of emissions that are produced as the result of human activities.
AOGCMs	Atmosphere/Ocean General Circulation Model or Atmosphere/Ocean Global Climate Model. Fully coupled atmosphere ocean Global Climate Model of the three dimensional global climate (see GCM).
Berg Wind	Warm dry airflow from the NE, commonly (but not always) caused by a coastal low off the west coast, predominantly in winter. Dry air descending off the continental plateau warms up and results in a hot dry wind - creating an opportunity for veld fires. Berg winds can occur as both strong and mild winds. Temperatures can rise to over 30 deg C.
Biodiversity	The variety of organisms found within a specified geographic region.
Biofuel	Liquid fuel produced from plant material (biomass) e.g. agricultural waste, waste from municipal landfills, wood, etc. and ethanol mixed together to form an equivalent to petrol for motor vehicles.
Carbon cycle	The term used to describe the flow of carbon (in various forms such as carbon dioxide) through the atmosphere, ocean, terrestrial biosphere and lithosphere.
Carbon Dioxide (CO_2)	CO_2 is a colourless, odourless, non-poisonous gas that is a normal part of the ambient air. Of the six greenhouse gases normally targeted, CO_2 contributes the most to human induced global warming. Human activities such as fossil fuel combustion and deforestation have increased atmospheric concentrations of CO_2 by approximately 30 percent since the industrial revolution. CO_2 is the standard used to determine the “global warming potentials” (GWPs) of other gases. CO_2 has been assigned a 100 year GWP of 1 (i.e., the warming effects over a 100 year time frame relative to other greenhouse gases).
Carbon footprint	A measure of a person’s or business’s carbon dioxide impact, calculated by adding the various components that create carbon dioxide, for example use of fossil fuels in traveling, heating, etc.
Carbon sink	An area that acts as carbon reservoir where carbon is stored for the longer term (for example a forest), which absorbs more carbon dioxide than it gives out.
Clean Development Mechanism (CDM)	One of the three market mechanisms established by the Kyoto Protocol. The CDM is designed to promote sustainable development in developing countries and assist Annex I Parties in meeting their greenhouse gas emissions reduction commitments. It enables industrialized countries to invest in emission reduction projects in developing countries and to receive credits for reductions achieved.
Climate	The average course or condition of the weather over a period of years, as exhibited by temperature, humidity, wind velocity, and precipitation.
Climate change	A change in climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural variability observed over comparable time periods.
Convective rainfall	Typically summer rainfall related to thunderstorms, but also can be triggered by the arrival of cold fronts. This type of rain is associated with thunderstorm activity, heavy but localized rainfall, lightning and possibly hail.
Desertification	Land degradation in arid, semi arid and dry sub-humid areas resulting from various factors, including climate variations and human activities.
Ecosystem	The complex of plant, animal, fungal and micro-organism communities and their

	associated non-living environment interacting as an ecological unit. Ecosystems have no fixed boundaries; instead their parameters are set according to the scientific, management, or policy question being examined. Depending on the purpose of analysis, a single lake, a watershed, or an entire region may be considered an ecosystem.
Emission taxes	Taxes levied on air or water emissions, usually on a per ton basis. Emission taxes provide incentives for firms and households to reduce their emissions and therefore are a means by which pollution can be controlled. The greater the level of the emissions tax, the greater the incentive to reduce emissions.
Emissions	Anthropogenic (human caused) releases of greenhouse gases to the atmosphere (e.g., the release of carbon dioxide during fuel combustion).
Endemic species	A species native to a specific location or region, occurring naturally in a specific region characterised by certain bio-geophysical features.
Estuaries	A somewhat restricted body of water where the flow of freshwater mixes with saltier water transported, by tide, from the ocean. Estuaries are the most productive water bodies in the world.
Extreme events	"An extreme weather event is an event that is rare within its statistical reference distribution at a particular place. Definitions of "rare" vary, but an extreme weather event would normally be as rare or rare than the 10^{th} or 90^{th} percentile." (IPCC 2001) Examples include extreme flooding, droughts etc
Fossil fuel	A naturally occurring organic fuel formed in the Earth's crust, such as petroleum, coal, or natural gas. Fossil fuels result from organic matter being laid down and compacted over very long periods of time (hence 'fossil'). This means that stocks of these fuels are finite (compare to renewable energy).
GCM	Global Climate Model / General Circulation Model. A computer driven numerical representation of the climate system based on the physical, chemical and biological components, their interactions and feedback processes. GCMs are applied as a research tool to study and simulate the climate, but also for operational purposes, including monthly, seasonal and interannual climate predictions.
GIS	Global Information System
Greenhouse gases/ radiatively active gases	Those gases (such as water vapour, carbon dioxide, tropospheric ozone, nitrous oxide, and methane) that are transparent to solar radiation but opaque to long-wave radiation, thus preventing long-wave radiation energy from leaving the atmosphere. The net effect is a trapping of absorbed radiation and a tendency to warm the planet's surface. The major greenhouse gases covered by the UNFCCC and Kyoto Protocol are carbon dioxide, methane, nitrous oxide and three trace gases (hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride). Ozone falls under the Montreal Protocol. 'Greenhouse gas forcing' is the relative effectiveness of greenhouse gases in restricting long-wave radiation from escaping back into space and the effects of changing concentrations of these gases on global climate.
Intense rainfall	A subjective term, typically referring to rainfall that is in the upper tail of the distribution of historical rainfall. A useful threshold for Cape Town is of the order of 20mm in 12 hours. This significant quantity of rain over a short period of time and has two impacts: stress on storm water drainage, causing flooding of streets, and high input into streams, causing flooding of rivers.
Intergovernmental Panel on Climate Change (IPCC)	A panel established jointly in 1988 by the World Meteorological Organization and the United Nations Environment Programme to assess the scientific information relating to climate change and to formulate realistic response strategies.
Inversions	Cold surface air overlain by a warmer elevated layer of air, suppressing vertical motion in the atmosphere. The net consequence of relevance to the city is the build up of pollutants near the surface and leading to "brown haze". Most frequent in winter on clear windless days, particularly preceding the onset of a frontal system. The lack of wind further exacerbates the impact of the inversion by preventing mixing and dispersion of the layers. The situation can persist for a number of days.

IPCC Assessment Reports	Reports by the Intergovernmental Panel on Climate Change. Since the IPCC's inception, it has produced a series of assessment reports (1990, 1995, 2001, 2005 and the latest in 2007).
Mediterranean type climate	The wet winter and dry summer seasonality of precipitation is the defining characteristic of this climate. Extremely dry summers are caused by the sinking air of the subtropical highs and may last for up to five months. Wet winters are dominated by mid-latitude cyclones associated with low-pressure systems.
Microclimates	Generally the climate of small areas, especially insofar as this differs significantly from the general climate of the region.
Mitigation	An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases.
MSW	Municipal Solid Waste
Nitrogen cycle	The steps by which nitrogen is extracted from the nitrates of soil and water, incorporated as amino acids and proteins in living organisms and ultimately reconverted to nitrates.
Precipitation	Water that falls from the sky in various forms, e.g. rain, snow, hail, mist.
RCM	(Regional Climate Model) and Empirical downscaling are two complementary methods used to producing projections on a horizontal resolution from point scale to about 50 km.
RCM (Regional Climate Model)and Empirical downscaling	Two complementary methods used to producing projections on a horizontal resolution from point scale to about 50 km.
Renewable energy (RE)	Energy obtained from sources that are essentially inexhaustible (unlike, for example, fossil fuels - of which there is a finite supply). Renewable sources of energy include wood, waste, geothermal, wind, photovoltaic, small hydro and solar thermal energy.
Riparian zones	The bank of a body of flowing water; the land adjacent to a river or stream that is, at least periodically, influenced by flooding.
Scenario	A plausible and often simplified description of how the future may develop based on assumptions of key driving forces. Each climate change scenario depends on future governmental decisions made about greenhouse gas emissions. A range of climate change scenarios leads to climate change predictions, dependant upon the scenario followed.
Seasonality	Periodic fluctuations in the climate related to seasons of the year e.g. wet winters, drier summers.
Sustainable development	A broad concept referring to a country's need to balance the satisfaction of near-term interests with the protection of the interests of future generations.
Tipping point	A point at which sudden and extensive climate change becomes inevitable.
Trend	Evidence of change from observations over a period.
Vulnerability	Defines the extent to which climate change may damage or harm a system. It depends not only on the sensitivity of a system but also on its ability to adapt to new climatic conditions.

Appendices

Appendix 1: PESTLE analyses of resources, sectors and systems

A PESTLE analysis facilitates the understanding of a particular entity (e.g. organization, sector or resource) at a particular time by providing a complete picture of the external factors that affect it.

P – Political	This analysis identifies political pressures and influences on the entity (organization/system/resource).
E – Economic	This analysis examines the local and national economic pressures and influences.
S – Social/sociological	This aspect takes into account how societal changes affect the organization/system/resource.
T – Technological	This aspect analyses how changes in technology affect the entity.
L – Legal	This examines how various types of legislation affect the entity.
E – Environmental	This examines the effect on the entity of local, national and global environmental issues.

The following section contains summaries of the PESTLE analyses carried out on the prioritised sectors of the Western Cape's natural resources and systems, infrastructure, economic sectors and livelihoods, as well as disaster management systems (in the case of extreme weather events such as flooding), and provides a snapshot of the current situation in the prioritised aspects.

1. Natural resources and systems

PESTLE analysis: Terrestrial biodiversity (Western Cape)

Aspect	*Relevant issues*
Political	Political factors include perceived value of biodiversity and Nature-Based Tourism (NBT); and of aims of conservation agencies and NGOs. Issues of land tenure, land reform, and land use change as well as population influx into the Western Cape also have an impact. Relevant international agreements: international biodiversity commitments (Convention on Biodiversity (CBD), the Convention on Trade in Endangered Species (CITES). Disaster management is another important political factor.
Economic	Economic factors focus on perceptions of the value of nature-based tourism and tourism market development; water demand (new dams); competition between development and conservation objectives (e.g. NEMA regulations); poorly quantified and under-appreciated value of ecosystem services. Other issues: development of indigenous crops and genetic resources (e.g. medicinals); costs of conservation estate; costs of wildfires and wildfire management. Opportunities exist in carbon sequestration.
Social	Poor socio-economic conditions in much of the Western Cape are associated with low appreciation of esoteric 'bio-diversity', possibly balanced by perceived heritage value of biodiversity. Other negative attitudes: low sense of ownership of wild nature, fear of wildfire and other aspects of wild nature, and favouring of alien invasive species due to their perceived benefits. There is a low but growing involvement of black professionals in conservation.
Technological	Characterized by fragmented, often curiosity-based research (although biodiversity data and information are accessible), governed by capacity

	building and the application of NEMA regulations. There is a growing understanding of threats and of the viability of genetic resources. Drug discovery, the selection of indigenous crops, and awareness of the efficacy of indigenous medicinals are important aspects. There is generally a poor understanding of fire management.
Legal	Legal aspects include policies and acts such as NEMA, the Biodiversity Act and those relating to land reform, land tenure, land ownership and stewardship (conservancies). Other relevant legislation: water law, tax law and carbon credit arrangements. Liability, indemnity and insurance against wildfire and related events are relevant at all levels of society.
Environmental	Issues revolve around environmental integrity and health, disaster and risk management and assessment, water yield and water quality, quality and carbon content of soil, the maintenance of biodiversity. Little state investment in conservation and wildlife management in this province over the past decade or more, with results like the collapse of fire management strategies and of research/implementation capacity. This situation appears recently to have improved somewhat. Synergistic negative impacts that exacerbate climate change stresses include pesticides and other damaging agricultural practices, extractive over-use (over-harvesting), impact of invasive alien species and loss of land to agriculture. **Climate variability, extreme climate events and climate change are major and under-appreciated factors.**

PESTLE analysis for regions of the Western Cape

REGIONS	POLITICAL	ENVIRONMENTAL
SOUTH-WEST	Land tenure and land reform; land use change; population influx into the Western Cape.	Relevant issues are water yield and water quality; invasive alien species; loss of land to agriculture; maintenance of biodiversity; disaster and risk management and assessment (drought, flood and fire). **Climate change, variability and extreme events.**
NORTH-WEST	Land tenure and land reform; land use change.	Main issues are invasive alien species; loss of land to agriculture; maintenance of biodiversity; disaster and risk management and assessment (drought). **Climate change, variability and extreme events.**
SOUTH COAST	Land use change.	Issues relate to invasive alien species; loss of land to agriculture; water yield and water quality; maintenance of biodiversity; disaster and risk management and assessment (drought, flood and fire). **Climate change, variability and extreme events.**
KAROO	Land tenure and land reform; land use change.	Issues focus on climate variability; disaster and risk management and assessment (drought)**. Climate change, variability and extreme events.**

Water PESTLE analysis

Aspect	*Relevant issues*

Political	Policies for equity, redistribution, poverty reduction and reallocation of resources govern access to water (e.g. National Water Act), implying accelerating demand for water. Free basic water (FBW) provided by all municipalities ensures access of the poor to clean, safe water. Water Allocation Reform (WAR) developed by DWAF to undertake reallocation. Security of supply becoming an issue. Perceptions regarding future climate change may appear less urgent than needs for poverty relief in W. Cape.
Economic	*Water supply:* Urban centres are expected to grow, thus increasing water supply demand, also intensification of irrigated agriculture and other new demands for water. Rapid urban development including on the southern coast where water supply is already an issue. Unit costs of water increasing. Drying is likely to increase fire danger. Costs of flood damage in the Western Cape from 2003-2006 were R927 million. Climate change is likely to increase flood episodes (and/or their intensity).
Social	The poor are particularly vulnerable to a lack of clean drinking water, poverty being the main cause for drinking unsafe water. Diarrhoeal disease is the third largest cause of disease in children under the age of five in SA (Bradshaw *et al*, 2003). SA is a signatory to Millennium Development Goals, which aim to improve health through access to clean, safe water. Poverty is also the reason for building on flood-prone land in urban areas, being a significant cause of climate-related disaster in the Western Cape (e.g. storms of 2003-2006).
Technological	Water management sector is paying little attention to climate change; or current practices may appear to be adequate. In previous five years, DWAF implemented measures to reduce demand, ending growth in water consumption in Western Cape Water Supply System (WCWSS). New water schemes need only be implemented later than planned. Desalination costs are decreasing and water efficiency is increasing although some areas use inefficient practices. Groundwater: a very valuable resource, e.g. Table Mountain Group aquifer, although quantities unknown.
Legal	Legal aspects are governed by political imperatives (above). The Constitution and other legislation govern how water is used, e.g. National Water Act , Water Services Act, National Environmental Management Act (NEMA), Marine Living Resources Act, NEMA: Biodiversity, Conservation of Agricultural Resources Act, Local Government Act, Development Facilitation Act, World Heritage Convention Act. International obligations include RAMSAR convention, World Heritage Convention, Bonn Convention.
Environmental	95% of the main river ecosystems of three of the four W. Cape Water Management Areas (Berg, Breede, Gouritz) are critically threatened (Nel *et al*, 2004). 75% of the river ecosystems in the Olifants/Doring are threatened. These catchments are now in a water deficit. Impacts: over-extraction, dams, pollution, alien invasive species, inappropriate land management. Riverine ecosystems also required for flood attenuation: flat areas with vegetation slow flood waters. Desiccation could result in diminished capability. Estuaries threatened by upstream abstraction.

PESTLE Analysis - Coastal and marine

Aspect	*Relevant issues*
Political	Lack (perceived) of political will to 'regulate' settlement and deter settlement in/near sensitive coastal areas. Policies such as 'water/electricity for all' increase pressure on resources such as water (i.e. runoff), which alters hydrodynamic flow patterns and sediment regime or inputs to the coastal zone. Shift of priorities allowing more intensive use of shoreline habitats for

	'consumptive' & 'non-consumptive' use. Inadequate implementation of international commitments and standards (e.g. RAMSAR sites).
Economic	Exponential rise in coastal land/property value. Coastal zone: a major resource for expanding tourism. Increased demand for property, recreational and bathing areas. Unregulated settlement and settlement in and adjacent to sensitive coastal areas by the poor. Intensity of coastal zone developments, profiteering. Harbour and marina expansion.
Social	Increased human population density, distribution, growth and utilisation in and near coastal zone. Increased demand for recreational and safe bathing areas. Unregulated settlement and settlement in sensitive areas. Change in land use. Supplementation of basic human needs (food) by 'consumptive' use of coastal biota & habitats. Popularisation of 'marina' type lifestyle. Lack of public understanding/awareness of fragility of coastal ecosystems.
Technological	Insufficient research and development. Inappropriate practices in catchments alter hydrodynamic flow patterns and sediment regime or inputs to the coastal zone. Insufficient planning, lack of decision-support for planning at local level. Lack of management capacity, integrative management, and public awareness.
Legal	A variety of National Policies (White Papers) relate to coastal management to a greater or lesser degree, including: White Paper for Sustainable Coastal Development in South Africa (2000); White Paper on Environmental Management Policy (1997); White Paper on Integrated Pollution and Waste Management for SA (2000); White Paper on Marine Fisheries Policy for SA (1997); White Paper on spatial planning and land-use management (2001). DEAT has drafted the National Environmental Management: Coastal Zone Bill (2006), aimed at giving legal status to the White Paper for Sustainable Coastal Development in South Africa. Most important in terms of coastal management & climate change, the Coastal Zone Bill (2006) and the White Paper for Sustainable Coastal Development in South Africa [shortened].
Environmental	Under global and regional climate change, thresholds of capacity have been approached. Fragmentation and degradation of natural coastal zone. Physical disturbance of coastal environments altered coastal dynamics. Anthropogenic activities & development in sensitive areas (e.g. dunes). Harbours and inappropriate practices in catchments alter hydrodynamic flow patterns and sediment regime or inputs to the coastal zone, affecting sediment budgets, shoreline evolution, etc. Intensity of use of shoreline habitats for 'non-consumptive' use. Increased 'footprint' and impacts of outfall pipelines. Harbour/ marina expansion.

2. Economic sectors

Pestle Analysis - Western Cape Climate Change - Agriculture

Aspect	*Relevant issues*
Political	Land reform and transformation of the sector is a national priority, thus any impacts or mitigating measures relating to climate change and agriculture taken on a provincial level would have to be directed at national level through DOA. Success of the land reform programme will be highly dependent on impacts of climate change especially where emerging farmers are settled on marginal land or in vulnerable areas. Market access as facilitated by international trade agreements is equally important.
Economic	Agriculture provides a small but significant input to national and provincial economies (5.2% of the W. Cape's Gross Regional Product in 2001), but W. Cape generates about 23% of total value added of agriculture sector in SA and W. Cape export-driven enterprises contribute >50% of national agricultural exports. Climate change impacts: lower productivity and product quality, with negative effects on income. Low economic resilience. Farm-level net income has declined considerably in recent years (escalating input costs, global oversupply, etc.). Economic impacts will be strongly informed by global market conditions and impacts of CC on them (competitor regions more/less affected).
Social	Trends are for relative stability/ increases in employment, but with a shift to casual/seasonal employment (primarily in response to recent labour legislation) impacting negatively on communities. Farm workers and those in agriculture-dependent industries are highly dependent on agriculture for livelihood. Negative impacts of CC and adaptation (e.g. through mechanization) will bring job losses exacerbating existing social challenges in rural areas. Urbanisation of jobless people will occur, creating pressures on towns and cities. Climate change might force agricultural activities to shift, e.g. from North-West/Swartland to Southern Cape/Overberg: substantial costs of re-building storage/ processing infrastructure and relocating work force, plus re-establishing crop. CC-induced changes in agricultural commodities, e.g. more suitable crops, require staff re-training.
Technological	Competitiveness and profitability depend largely on improving yields of high-quality product without forfeiting volumes, cost-efficiency or environmental sustainability under difficult climatic/ soil conditions. This endeavour has become strongly science-based and technically demanding. Enterprises lacking such skills will become increasingly uncompetitive, especially with added pressure of climate change. New/ improved technologies already developed could help adapt to climate change and reduce negative impacts. Most large industry associations provide technology transfer to members. Currently no government extension services to commercial agriculture; extension services to emerging farmers and farmers from previously disadvantaged communities are under-capacity.
Legal	The legal framework comprises environmental legislation including water, health and safety legislation, labour legislation, international trade legislation, land reform and transformation legislation, tax legislation, intellectual property rights, plant/animal breeders' rights.
Environmental (all externalities)	Climate change impacts on physical resources include: water supply and quality, soil, atmospheric CO2, fluctuations in resource supply e.g. rainfall, and changes in seasonality e.g. increasing summer rainfall. Temperature changes will impact on production and quality of all commodities. Increased wind speed will, along with increasing temperatures, contribute to rising evapotranspiration rates and thus faster soil moisture reductions. Both beneficial and non-beneficial associated biological organisms will be impacted by CC and thus cause altered interactions with crops and livestock.

	Negative organisms include weeds, pests and diseases, all likely to become more problematic under CC. In-migration of new weeds; pests and diseases would demand rapid managerial responses. An integrated view of farming systems and how whole systems (biological and physical) will shift in response to CC is a requirement for effectual adaptation within agriculture. Once harvested, perishables require cold chain infrastructure, which increasing temperatures will strain, increasing risk of infection and causing economic losses.

PESTLE Analysis - Fisheries

Aspect	*Relevant issues*
Political	Marine resources fall under aegis of DEAT: Marine and Coastal Management (MCM). Driven by Fisheries Policy, Marine Living Resources Act (1998), rights allocation mechanisms and equity requirements (transformation). Long-term allocation of fishing rights in domestic commercial sector is primary political concern. CC impacts or mitigating measures would be directed at national level through DEAT. International commitments/agreements are pertinent to any decisions relating to climate change, e.g. conservation, catches.
Economic	W. Cape is the hub of commercial fisheries in SA. Commercial and recreational fisheries provide small but significant input to national economy (less than 1% of GDP); relatively higher for regional economy but still low (no estimates). Complex, diversified industry. Declining resources (over-fishing). Climate change (CC) impacts/measures will impact both primary resources (primary drivers of fisheries income, employment and infrastructure) and secondary (less capital intensive) resources. CC may result in changes to Operational Management Procedures (OMPs) and reduction of Total Allowable Catches (TACs). CC effects are likely to be lower/higher catch rates.
Social	CC effects will compound existing situation of declining resources for allocation and reduced catch rates, likely to lead to job losses in most fishing sectors. Coastal communities dependent on fishing for livelihood and those dependent on fish processing industry will be impacted negatively (reduced household income/job losses). Relocation of resources, factories and staff may occur. [Appendix of fisheries sectors /employment].
Technological	Technology plays a big role in the fishing industry, but no alternative technologies are currently perceived as mitigating CC impacts. Generally innovative; continually adjusting fishing gear, fishing methods, etc. to accommodate changes.
Legal	Driven by Fisheries Policy, Marine Living Resources Act and regulations (1998), rights allocation mechanisms and equity requirements. Changes to management structures to accommodate CC including basis for allocation of fishing rights, changes to OMPs etc, need to take into consideration existing legal framework, especially the MLRA. International agreements.
Environmental	Primary impact of CC is sea surface temperature (SST) rise causing changes in salinity, currents, warm water intrusions, reduced/increased upwelling etc.; all impacting on productivity. Changes in recruitment patterns (changed seasonal characteristics) – productivity, availability of species. Wind stress is also a factor. Need for more research in order to identify stresses and differentiate CC from better-understood effects e.g. ENSO. Ecosystem approach to fisheries could incorporate CC effects into fisheries management.

PESTLE Analysis - Tourism

Aspect	*Relevant issues*

Political	The Provincial White Paper (1996) sets out a number of qualitative and quantitative targets for tourism; government has a defined vision for the industry growth. Inadequate government funding for tourism - noted in the provincial white paper. Need for better co-ordination of public resources. Province envisages that the tourism sector will provide the bulk of new jobs.
Economic	The industry in the W. Cape is large, with a significant concentration in Cape Town and environs. Multiplicity of stakeholders and role-players. Tourism GDP statistics are not available as tourism is lumped with other sectors such as wholesale and retail trade. It is clear that tourism is a growth industry in the province, particularly in terms of overseas visitors.
Social	Clear need for more involvement of PDIs in the industry, e.g. potential for more domestic township tourism to increase and broaden the beneficial social impacts of tourism.
Technological	Lack of tourist-specific infrastructure (public facilities and tourist information).
Legal	The legal framework includes the following: NEMA (National Environmental Management Act, 1998) makes provision for Environmental Impact Assessments (EIAs) on all major developments; hence tourism and related infrastructure development is subject to environmental legislation; Western Cape (DEA&DP) Spatial Development Framework (2005); Provincial White Paper on Tourism (1996); LUPO (Land Use Planning Ordinance); Integrated Tourism Development Framework.
Environmental	Growth in tourism brings growth in demand for natural resources such as water. Tourism can place increased pressure on eco-systems. Tourism is subject to seasonality: the bulk of visitors are in the province over the summer months. The outdoor / nature tourism market is growing (whale watching, birding, hiking, kayaking).

3. Infrastructure and economic resources

PESTLE Analysis - Energy

Aspect	*Relevant issues*
Political	The Western Cape Summary Status Quo Report published in June 2005 on an integrated energy strategy for the W. Cape has a focus on demand side management in terms of energy efficiency as well as on establishing energy independence in the W. Cape. Drastic electricity price increases are needed in South Africa but are not politically acceptable. Eskom is applying for an 18% tariff increase. The W. Cape is contemplating an Energy Agency to stabilize and ensure the energy service needs in the W. Cape economy.
Economic	W. Cape relies essentially on imported energy, primarily electricity (the current demand is for 3640 MW) and liquid fuels (for transport and industry). The bulk of electricity is imported from Mpumalanga with local electricity coming from the Koeberg nuclear station - installed capacity 1800MW. South Africa does not have sufficient reserve generation capacity to operate safely - as witnessed in the W. Cape in early 2006. The estimated cost of these outages is ZAR12 million. South Africa's electricity prices are amongst the cheapest in the world - >36c/kWh. The key economic consideration in relation to energy is the uncertainty, or risk, associated with unpredictable *access* to *affordable* energy in future.
Social	Increasing access to electricity does not automatically contribute to poverty alleviation; services also need to be improved. Urbanisation is placing increasing pressure on energy resources and infrastructure. Peri-urban usage of wood fuels and paraffin for cooking and space heating contribute significantly to the "brown haze" over built areas, and to GHG

	emissions. Use of paraffin and candles leads to health problems due to poor indoor air-quality and is the main cause of shack fires in poor households.
Technological	The local energy generation and distribution capacity in the W. Cape is inadequate; more use could be made of energy efficiency renewable energy technologies: thermal insulation, energy efficient AC, lighting and solar (SWH & PV), biofuels, wind. Climate change is expected to exacerbate the mismatch between increased loads on an already insufficient generation and distribution capacity: higher temperatures increase demand for air-conditioning; agriculture requires more irrigation systems. Eskom's transmission network needs to be strengthened, particularly in the W. Cape. RETs are less attractive in the short-term due to current electricity pricing.
Legal	National and Provincial policy encourages more sustainable energy systems. However, there are no legal requirements at National or Provincial level. The City of Cape Town is introducing a By-law for domestic solar water heating. National Government has developed a Biofuels Strategy which sets indicative targets for ethanol and biodiesel blends for liquid fuels. NERSA regulates the sector and will approve any local IPPs. The electricity sector is undergoing delayed restructuring with the introduction of the Regional Electricity Distributors (REDs), with Cape Town set to be the first.
Environmental	Transport is one of the fastest growing sectors of energy use; the 2003 Cape Town State of Energy Report states that transport contributes 54% of Cape Town's primary energy consumption. Accordingly transport has high levels of emissions. South Africa, and the Province is reliant on electricity which is generated from a mix which includes 92% from coal-based plant. In addition, the transmission infrastructure to the W. Cape has high visual impacts and gives rise to 10% electricity losses, which exacerbate the specific emissions.

PESTLE Analysis - Transport

Aspect	*Relevant issues*
Political	Relevant legislation includes: National White Paper on Transport (1996); Western Cape Provincial White Paper on Transport (1998); *Moving South Africa 1998* (guiding document by National Department of Transport (DoT). Taxi Recapitalisation Project (1996). In 2002, the province re-established the Department of Transport and Public Works with three main branches (public transport, transport infrastructure, property management). Fuel levy has been accepted at provincial level and is awaiting national approval.
Economic	Total income of the transport sector is estimated at R14bn (2002), of which an estimated R4.2bn was spent through tourism. Nationally, passenger transport contributes 60% of total land transport output; freight: 40% (2002). Freight: On national level, road transport by private enterprises has a market share of 77% of total goods transported, with an increasing trend. Cape Town port handles almost 8 million tons of cargo per year (2002). Buses and mini-bus taxis are in competition for market share, with mini-buses taking over.
Social	RDP's social goals: basic personal mobility for all. Urban sprawl and location of townships far from employment areas result in long daily commutes. In Cape Town, modal split between public/private/other is 49/44/47. Amongst those using public transport, 52% use rail, 39% minibus taxis, 9% buses. Safety and security issues in public transport prevent people from using it more. Metered taxi operator tariffs are unaffordable for locals and are almost only used by tourists.
Technological	Lack of integrated passenger transport services to facilitate inter-mode changes (e.g. from train to bus). Poor bus service levels make mini-bus taxis more convenient than scheduled buses. Cape Town's rail network is the most extensive of any South African city. Rail system upgrading and maintenance has been inadequate in recent years; poor operational performance of Spoornet. Ports' productivity is well below international benchmarks. Road system is inadequate.

Legal	Constitution (Act 108 of 1998) assigning public transport issues to the provinces. National Land Transport Transition Act, no 22 of 2000 (NLTTA).
Environmental	Transport sub-sector is responsible for 54% of the total energy use in Cape Town, and is the main contributor to local pollution problems. High consumption of petrol and diesel lead to high gaseous emissions. Although rail transport is much more energy efficient, there is a high annual growth in motor vehicle numbers leading to congestion on already stressed roads.

PESTLE Analysis – Air quality

Aspect	*Relevant issues*
Political	There is increasing political pressure to reduce / manage Cape Town's brown haze. The W. Cape may need to start preparing itself for meeting emission reduction targets in the global emissions context (in terms of the Kyoto Protocol, to which South Africa is a signatory).
Economic	Economic impacts of poor air quality are fires (damage) and health (increased diseases) and, potentially, on tourism.
Social	Air quality statistics (generally available only for Cape Town) show very poor outdoor air quality in many areas of Cape Town, particularly in low-income residential areas. Lack of energy/electricity and the use of solid fuels for heating and cooking are significant contributors to poor respiratory and nutritional health in these households (poor indoor air quality, lack of access to energy for cooking and space heating).
Technological	There are air quality management systems in place in Cape Town - needs to cover the Province - Dynamic Air Pollution prediction Systems (DAPPS).
Legal	Air Quality Management Act; Cape Town City Air Pollution Control By-law (2001); Khayalitsha Air Pollution Strategy; Cape Town City Energy Strategy.
Environmental	Main sources of particulate matter are power plants, vehicles, industry, household cooking and heating fuels, construction and waste incinerators. Negative impact on biodiversity. Air pollution and climate change are closely related - particulate matter in the atmosphere on a regional level has important climate impacts.

PESTLE Analysis - Health

Aspect	*Relevant issues*
Political	Need for better co-ordination of public resources.
Economic	The public health sector appears to be under-funded. Training and retaining of staff is a big challenge. Theft of government assets in hospitals adds a further economic burden. Climate change is predicted to affect the health of humans as well as the species and ecosystems on which humans depend - with economic consequences. The insurance industry will absorb this risk through pricing and recommendations and will play a role in helping society and business to adapt. Warming favours the spread of disease and invasive aliens (such as rats), and extreme weather events create conditions conducive to disease outbreaks.
Social	Strong drive from government to get communities more involved in taking responsibility for local health care issues. Poor communities suffer most from inadequate waste and water management. These communities are also vulnerable to poor air quality in peri-urban areas, largely induced by fuel emissions from cooking and space heating leading to respiratory disease.

Technological	Facilities are run down and inadequately resourced. Climate change will increase the demand on energy resources, for example for refrigeration of medications.
Legal	Policies laid down by Department of Health.
Environmental	Poor waste management and inadequate water sanitation impact on health systems and infrastructure.

Appendix 2: Informed adaptation to climate shift in Perth, Western Australia

Background

Western Australia and the Western Cape share similar climate regimes, and thus have a great deal in common with respect to agricultural, biological and physical characteristics. Both regions depend on 'reliable' winter rainfall due to their position within the belt of the westerly frontal systems that bring mainly winter rainfall. Their capital cities, Perth and Cape Town, both receive a long-term mean annual rainfall of approximately 900 mm. General circulation models (long-term climate change projection models - GCMs) project that both these regions are very likely to suffer a reduction in winter rainfall due to a southerly shift in this rainfall-bearing circulation feature. There are, however, also important differences between the two regions, the main ones being the size (with the metropolitan areas of Cape Town and Perth having a population of 3.25 million and 1.5 million respectively, and the generally lower income of potentially affected people in the Western Cape.

The observed shifts in rainfall in southwest Western Australia and the responses by government there provide a case study and insights for dealing with the impacts of the type of shorter- and longer-term droughts that have been recorded in the Western Cape.

Recent climate shifts in South-western Western Australia

South-western Western Australia has experienced a sudden, drastic decrease of roughly 15-20% in winter rainfall since the mid-1970s (Pitman *et al* 2004). This rainfall decrease occurred mostly in early winter, with fewer rain days and less rain on extreme wet days, and with a modest increase in spring rainfall. Researchers attribute at least some of this shift to global warming and anthropogenic climate change (Indian Ocean Climate Initiative (IOCI), 2002).

More recently, Pitman *et al* (2004) have suggested that about half of this change can be attributed to the massive land cover change in the region. Land clearing and conversion of a scrub and low forest to grassland (wheat fields) began in the 1920s. This conversion reached its peak rate in the 1960s when about one million acres (approximately 250 000 ha) per year were being cleared, tailing off in the 1980s when huge salinisation effects became apparent with rising water tables. Land degradation set in and many farmers were forced off their land (Flannery, 2006).

Climate modelling by Pitman *et al* (2004) attributes part of the reduction in rainfall to a decrease in the surface roughness of the cleared area (i.e. removal of trees shrank the surface drag on the moisture-bearing winds), allowing higher horizontal wind velocities and diminished vertical wind velocities, which reduced vertical moisture flux and convergence - resulting in less rainfall. Their results indicated that the moist, unstable air flowing inland from the west would increasingly pass over the crucial water catchments of Perth and the wheat belt, and ultimately result in augmented rainfall much further inland. This is in fact what has been observed in the rainfall records in that region.

This marked shift toward drier winter conditions has strongly affected water supplies and related ecosystems (Sadler 2003). The observed decline in rainfall in the southwest of Western Australia is reflected in a 42% decline in inflow into the Perth metropolitan reservoirs (see Figure A below). In Perth's water catchments, average stream-flows of the last quarter century are approximately 50% below those of the earlier part of the century. From 1911 to 1974 this was 338 GL (1 GL = 1 gigalitre = 1 billion litres) per annum, but from 1975 to 2002 it was only 164 GL, and in the years 1997-2002 it was even lower at 115 GL.

The region has also experienced a warming trend in the last 50 years corresponding broadly to the national and global trend.

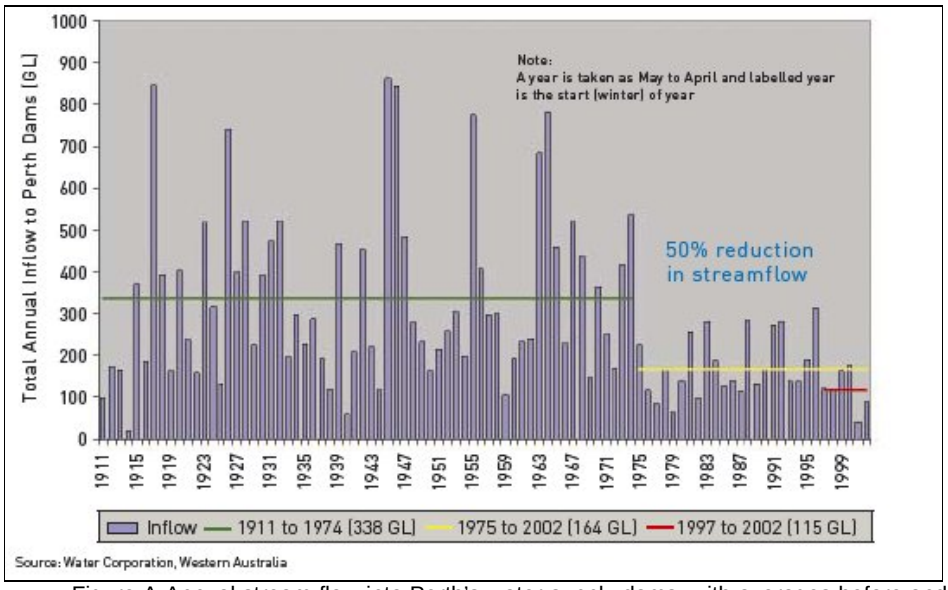

Figure A Annual stream-flow into Perth's water supply dams, with averages before and after the rainfall decrease of about 10-20% (depending on location), which occurred in 1974-1975. Note that the decrease in water supply is about 50%.

Key adaptive policy responses to dry climate between 1987 and 1995

By 1987, about a decade after the drastic reduction in rainfall, water managers were prompted to respond and the Water Authority announced a strategy of incremental water system adjustments. In an initial step, the system yield was written down by 13%. However, dry conditions continued between 1987 and 1995 and a new strategic plan, titled 'Perth's Water Future', was issued in 1995. This plan assumed, with understandable pragmatism, that 'the flows for the past 20 years were an extended drought' and that high flows would recur in the medium term. Only a year later, following the sustained failure of a wet winter and the outcomes of a workshop on climate variability and water resources, the Water Corporation finally concluded that a climate shift had occurred rather than an extreme drought event. The design basis of Perth's water system was radically adjusted at a cost of AU$ 500 million (approx. R2.4 billion)

It is interesting to note that the **agricultural sector**, by contrast, had fared very well in this climate shift up to the end of the last century. Due to an extensive introduction of minimum-till seeding practices in the wheat-belt as a water-efficient agricultural practice through the early to mid-1990s, the sector was able to adapt to the late start of the winter season and reduced rainfalls. Agriculture was, therefore, at that time mainly calling for advanced inter-seasonal forecasting technology rather than for more water.

In order to establish knowledge of climate variability and climate change in the Australian South West, the Western Australian Cabinet endorsed the establishment of the **Indian Ocean Climate Initiative (IOCI)** in 1997. This partnership is supported by state departments responsible for environment and water, conservation, land management and agriculture. Moreover, the Water Corporation, the Bureau of Meteorology, and the Fire & Emergency Services Authority contribute. The core research team of IOCI consists of the Bureau of Meteorology Research Centre and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) - Australia's national science agency.

The drought of 2001/2002 and the State Water Strategy for Western Australia

In 2001, after a quarter century of poor replenishing rains, the South West suffered an extremely dry year with the second lowest stream-flows on record (Fig. 3). Winter 2001 saw the worst inflow to the Perth metropolitan dams since 1914. Water supplies throughout the region were severely affected. Then, the following year (2002), the region was hit by agricultural drought that brought

massive crop failures in the wheat-belt, one of the most climatically reliable areas in Australia for winter crop production. Once again water supplies were strained to their limit. The 2001-2002 winter sequence represents the worst two-year drought on record and forms part of an eight-year sequence (1997-2004).

The water shortage of 2001/02 prompted further investment into new water sources as well as the use of a two-day-a-week sprinkler regime to help conserve water. Outstanding community support for the use of restrictions helped to deliver a 45 GL water saving during 2001/2002. Moreover, in response to the water supply situation the State Government established a task force to oversee a strategic response and to advise government on 'Our Water Future'. This process included public workshops throughout metropolitan and regional areas, informing the community on the situation and drawing on public comment on future options. These forums culminated in a Water Symposium in the State Parliament House with delegates being chosen by a range of methods, namely: nominations from the prior forums; people chosen randomly from the electoral roll and from applications to participate; nominations from particular interest and expert groups; and people chosen for their expert input. As an essential preparatory input to these various workshops, climate briefings were given based on the integration of IOCI research and CSIRO publications on global and national climate change.

This process led to the formulation of a State Water Strategy for Western Australia that was released by the State Government in 2003. The objective of the State Water Strategy is to ensure a sustainable water future for all Western Australians by:

- improving water use efficiency in all sectors
- achieving significant advances in water reuse
- planning and developing new sources of water in a timely manner
- fostering innovation and research
- protecting the value of water resources.

More specifically, the strategy set the following targets:

- To achieve a 14% reduction in consumption per person per year (i.e. 155kL) by 2012 for domestic consumers served by the Perth component of the Integrated Water Supply System.
- To establish a 20% reuse of treated wastewater by 2012.
- To require water conservation management plans for large water users before the renewal of a licence or a new licence is provided. The plan outlined water efficiency objectives and timeframes. Licence conditions require implementation of the plan to an agreed schedule.

The objectives were pursued through the following measures:

Domestic water demand management

Activities include the existing drought response measures involving two-days-per-week garden watering restrictions, a demand management program incorporating Waterwise initiatives, communications and marketing campaigns, a Government Rebate Program, a stepped pricing structure and support for major non-residential customers for improved water efficiency.

The Waterwise Rebate Program was introduced to encourage West Australians to be more water-efficient by offering rebates of up to 50% on a variety of waterwise products, from swimming pool covers and irrigation systems to showerheads and washing machines. From February 2003, the Government provided AU$7 million (approx R34.3 million) for the first year of the rebate programme. The program was later expanded due to its great success. Already over 260,000 rebates have been processed with an annual saving of 4.6 billion litres of water, which will result in a saving of 52 billion litres of water over the life of the rebated products.

A Water Efficiency Labelling Scheme (WELS) was established to label waterwise products including dishwashers, washing machines, toilets, urinals, showers, and taps. Another labelling

scheme was established for service providers and businesses such as Waterwise plumbers, garden centres or garden irrigators.

In line with its 2003 Water Strategy, the Western Australian Government substantially increased the price paid by Water Corporation domestic customers who consume more than 550kL (1 kL = 1 kilolitre = 1000 litres) per year in excess of movements in the Consumer Price Index to encourage the adoption of waterwise practices. For metropolitan consumers, the price for water consumed between 550-950kL was increased by up to 20% to over AU$1.20 (approx. R5.9) per kilolitre. For water consumed above 950kL, the price was increased to more than AU$1.50 (approx. R7.4) per kilolitre. In recognition of the impact on pensioners, large families and low-income earners, the Government limited increases in the price of water for Water Corporation domestic customers consuming less than 550kL.

Increasing water efficiency in agriculture

A review of irrigation activities throughout the State was conducted by an independent taskforce: the Irrigation Review Steering Committee, which included three major growers. The review fulfilled the following purposes:

- establishing the amount of irrigation water supplied and used within Western Australia together with the economic and social benefits generated by such usage
- identifying the likely future forms, scale, locations, water-needs and economic benefits of irrigated agriculture in Western Australia while considering factors such as water availability, environmental impact, climate change, etc.
- identifying opportunities for improving the efficiency with which irrigation water is delivered and used.

Moreover, a 'Waterwise on the Farm' programme is being delivered by the Department of Agriculture. The programme delivers training and information on using water efficiently, including technical support for demonstration farms and the development of a web-based integrated information system for climate and water use.

Promoting water re-use

In the State Water Strategy, the Western Australia Government commits to achieving 20% reuse of treated wastewater by 2012. The Strategy highlights the potential for recycling to provide water 'fit for purpose' for irrigated horticulture, green space irrigation and industry as well as the potential for managed aquifer recharge to increase water availability in groundwater systems and to maintain environmental values. For example, it has been calculated that the total annual demand for water in the Perth metropolitan area is currently almost 600 gigalitres. The 100 gigalitres of water available from the metropolitan treatment plants can be used to provide 'fit for purpose' water for the above mentioned use.

Achieving the 20% target has been promoted by establishing a regulatory framework, trial projects, and a communication and marketing strategy addressing community concerns associated with water recycling. Moreover, the AU$28 million (approx. R137 million) Kwinana Water Reclamation Plant (KWRP) became operational in late 2004. The reclamation plant reduces industry demand for water supply scheme water by up to six gigalitres a year, which is equivalent to about 2% of Perth's total water supply scheme water use. It treats about 24 million litres a day of secondary treated wastewater from another wastewater treatment plant. The high quality industrial grade water stream produced (about 17 million litres/day) is supplied to industry in place of scheme and bore water.

Developing new resources

The Water Corporation began to address declining rainfall in 1996. Concerned at poor rainfall over two decades, it accelerated a detailed source development plan based on Perth's Water Future, a major study completed in 1995 that clearly identified water sources and demand 50 years ahead. The plan sought to restore the balance in the system by 2002 with completion of the Harvey Dam

being the final element. Unfortunately the drought of 2001 and 2002 required additional investment in new sources, taking the total investment to AU$665 million (approx. R3.25 billion) in a decade (Water Corporation website). During this period, supply capacity has been doubled. More specifically, the following water resources have been developed:

Table 1: Additions to the Perth water supply network since 1996

Additions to the water supply network since 1996	**Additional Water Available**	**Cost** (AU$)
1996 Increased groundwater production and new borefields in Pinjar	17.9 million kilolitres annually	$15 million
1997 New Trunk Main delivering water from Yokine to Wanneroo South Dandalup Pumpback	6.9 million kilolitres annually	$37 million
1999 New borefields at Neerabup New state of the art pumping station at Belmont	26 million kilolitres annually	$45 million
2000 Additional groundwater sources at Neerabup, South Whitfords and Lexia	30.5 million kilolitres annually	$68 million
2001 Southern Trunk Main Harris Pumpback New dam in Harvey delivering new supplies from the South West to Perth	34 million kilolitres annually	$275 million
2002 Three new bores in Perth's northern suburbs	15 million kilolitres annually	$37 million
2002 New groundwater project in Mirrabooka	6 million kilolitres annually	$10 million
2003 Samson Brook Pipehead Dam	8-14 million kilolitres annually	$31 million
2003 Wellesley Creek Pumpback	8 million kilolitres annually	$16 million
2006 Perth Seawater Desalination Plant	130 million litres per day	$387 million

Source Water Corporation (Western Australia)

The latest development is the Perth Seawater Desalination Plant, which began delivering drinking water into Perth's public supply system on 19 November 2006. It is now Perth's largest single source of water and supplies 17% of the city's needs. The plant uses the desalination process known as reverse osmosis. The capital cost of the plant and ancillary infrastructure was AU$387 million (approx. R1.9 billion). The potential cost impact for households is less than one dollar per week at AU$44 (approx. R216) per year. To reduce the environmental impact, electricity for the plant will be produced from the Emu Downs Wind Farm, located 200 km north of Perth.

Financing research and including results in planning

The Western Australia Government has also responded to increasing climate variability by funding research. For example, the Premier's Water Foundation to promote and enhance water-related research and development activities within Western Australia was established in 2003 with an initial budget of AU$3 million (approx. R 15 million) from the State Government. In 2005, a second round of grants was issued totalling AU$ 3.1 million. Furthermore, the Government continues supporting the Indian Ocean Climate Initiative and information from climate modelling will be used to guide water resource and supply decisions.

Possible future projects

An intriguing suggestion by Pitman *et al* (2004) is that Western Australia could somewhat mitigate the decline in rainfall by undertaking a reforestation project that would replace the surface roughness over the south-western region. Clearly more research would be required before undertaking such a large task.

Conclusions

Western Australia, and Perth in particular, have adapted to a substantial reduction in rainfall within the range projected for the western Cape over the next thirty years through a range of innovative and synergistic responses that have both reduced water demand and increased supply. These strategies were achieved without inducing a substantial economic impact in the region and in fact

were likely to have increased the number of jobs and level of expertise in the region while ensuring a sustainable future for the urban region, at least. The success of the policy interventions appears to have been underpinned by a substantial reliance on efficient public service skill and delivery, co-operation and buy-in from the private sector and general population, and aided by a relatively low urbanization rate.

The important lessons to be learned are that adaptation to climate change can bring tangible benefits with regard to securing and managing water resources in any instance. The key difference between this region of Western Australia and the Western Cape region of South Africa, however, is the presence in South Africa of the mountains. These provide a barrier to moist westerly winds, forcing uplift and precipitation. From this point of view, the Western Cape is not as vulnerable to climate change caused by land use change as is the West Australian wheat-belt. But it does suggest that the Western Cape mountain catchments are an extremely important part of water resource sustainability and should therefore be looked after as such.

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Western Australian Government 2004: Securing our water future - A State Water Strategy for Western Australia - One year Progress Report
http://portal.water.wa.gov.au/portal/page/portal/PlanningWaterFuture/StateWaterStrategy

Western Australian Government 2006 Draft State Water Plan.
http://portal.water.wa.gov.au/portal/page/portal/PlanningWaterFuture/StateWaterPlan

Appendix 3: Schedule of meetings with stakeholders

	STAKEHOLDER MEETING	VENUE	DATE
1	West Coast Industry Focus Meeting	Saldanha Council Chambers	21 September 2006
2	Local Government Focus Meeting	CWDM Council Chambers	22 September 2006
3	Labour Focus Meeting	Paarl Town Hall	28 September 2006
4	West Coast District Municipality	Morreesburg Council Chambers	07 November 2006
5	Agriculture - Citrus Fruit	Goedehoop Citrus, Citrusdal	08 November 2006
6	Agriculture - Fruit, Wine, Cereals, Livestock	Elgin Country Club	14 November 2006
7	City and Business	Leeusig Building Cape Town	16 November 2006
8	Agriculture - Fruit & Vegetables	Ceres	21 November 2006
9	Agriculture - Wine Livestock Fynbos	Stellenbosch University	22 November 2006
10	Agriculture - Potatoes & Rooibos	School Hall, Clanwilliam	28 November 2006
11	**Stakeholder Workshop**	**Kirstenbosch**	**30 November 2006**
12	Interdepartmental, W C Government	Cape Town	06 December 2006
13	Agriculture	Elsenburg Agricultural College	07 December 2006
14	**Stakeholder Workshop**	**CP Nel Museum, Oudtshoorn**	**12 December 2006**
15	Cape Town City & Business	Leeusig Bld, Cape Town	16 December 2006
16	Air Quality Focus Meeting	Cape Town	10 January 2007
17	Labour Focus Interview - NUM	Bellville	12 January 2007
18	Faith Based Communnities Interview	West Lake	18 January 2007
18	Interdepartmental, W C Government	Cape Town	19 January 2007
20	Khayelitsha Development Forum	Khayelitsha	21 January 2007
21	Wine Industry Leaders	Stellenbosch	23 January 2007
22	Cape Town Business - Port Focus	Port Of Cape Town	26 January 2007
23	Biodiversity Focus Meeting	Kirstenbosch	26 January 2007
24	CDM Meeting	OneWorld Offices	26 January 2007
25	Agriculture - cereals	Stellenbosch University	29 January 2007
26	**Stakeholder Workshop**	**Kirstenbosch**	**01 February 2007**
27	Fisheries Focus Meeting	MCM Offices	07 February 2007
28	**SALGA**	**Bellville**	**08 February 2007**
29	Energy Focus Meeting	Cape Town	12 February 2007
30	Stakeholder Workshop	George	22 February 2007
31	Mitchell's Plain Development Agency	Mitchell's Plain Town Centre	28 February 2007
32	Community Communications Meeting	Kirstenbosch	28 February 2007
33	Port Focus - NPA Exco	Port Of Cape Town	13 March 2007
34	PDC Meeting	PDC Offices, CPT	13 March 2007
35	Disaster Management Workshop	Cape Town	20 March 2007
36	S Robinson Premier's Office	Premier's Office	27 March 2007
37	Prov departmental meeting - Agriculture	DOA Offices	02 April 2007
38	SALGA	OneWorld Offices	20 April 2007
39	PDC Focus Meeting	Leeusig Building, CPT	19 April 2007
40	Prov departmental meeting - Treasury	8 Wale Street, Cape Town	23 April 2007
41	Disaster Management Services	DMS Offices, Parow	02 May 2007
42	Prov dept. meeting - Social Development	Social Development Offices, CPT	02 May 2007
43	Prov dept. meeting - Economic Devlpt.	Waldorf Building, CPT	04 May 2007
44	Prov departmental meeting - DEA&DP	7 Wale Street, CPT	07 May 2007
45	Prov departmental meeting - DWAF	OneWorld Offices	08 May 2007
46	Prov departmental meeting - Premiers Office	Wale Street, Cape Town	08 May 2007

Appendix 4: Literature review directory

Subject	File Name	Document Title	Theme/s and notes (where indicated)
Adaptation Policy Technical Framework Working Papers	Assessing Current and Socio-Economic Conditions, T3.pdf	Assessing Current and Socio-Economic Conditions, T3	Characterising socio-economic conditions and drivers with indicators; relating these indicators to climate analyses; integrating adaptation to climate change to sustainable development objectives
Adaptation Policy Technical Framework Working Papers	Assessing Current Climate Change Risk. Pdf	Assessing Current Climate Change Risk.pdf	Focuses on how to assess the historical relationships between society and climate hazards. Key concepts related to climate change risk are outlined, conceptual models that can be used to assess climate change risk over the short- and long-term planning are outlined.
	Assessing Future Climate Change Risk.pdf	Assessing Future Climate Change Risk.pdf	Describes how climate-society relationships may change under climate change and discusses how climate change information can be applied within a variety of risk assessment.
	Scoping and Designing an Adaptation Project.pdf	Scoping and Designing an Adaptation Project	Describes the process to scope and design projects for developing adaptation strategies using the APF process among others.
	Formulating an Adaptation Strategy.pdf	Formulating an Adaptation Strategy.pdf	Outlines how to formulate an adaptation strategy, policies and measures
	Continuing the Adaptation Process.pdf	Continuing the Adaptation Process	The paper describes how adaptation may be incorporated
	Assessing Vulnerability for Climate Change Adaptation. pdf	Assessing Vulnerability for Climate Change Adaptation.pdf	Provides framework for using vulnerability assessment criteria to guide the adaptation process
California Climate Change Centre	Climate Change Action Team' Report to Gov. Schwarzenegger and the Legislature. pdf	Climate Change Action Team' Report to Gov. Schwarzenegger	The report proposes measures to ensure that California's changed emission targets are met
	Preparing for climate change in California, opportunities and constraints for adaptation. pdf	Preparing for the impacts of climate change in California	The paper examines California's opportunities and constraints for managing the impact of climate change. It reviews the literature on adaptation and provides examples from selected sectors to illustrate the constraints and limits to the ability to adapt
Climate Change Response Strategy and Action Plans	Australian Gov., Climate change scenarios for initial risk assessment of risk in a Climate Change ordinance with risk management guidance	Australian Gov., Climate change scenarios for initial risk assessment of risk in a Climate Change ordinance with risk management guidance	Report develops scenarios for assessment of risks recommended in the publication "Climate Change Impacts and Risk Management: A Guide for Government and Business"
Climate Change Response Strategy and Action Plans	Australian Gov., Climate Change Risk and Vulnerability	Australian Gov., Climate Change Risk and Vulnerability	Using a risk management approach, the report identifies the sectors and regions that might have the highest priority for adaptation planning
	Australian Gov., Climate Change Impacts & Risk Management	Australian Gov., Climate Change Impacts & Risk Management a Guide for Business & Government	Provides a guide for integrating climate change impacts to into risk management and other strategic planning activities in Australian public and private organisations
	Canada's National Implementation Strategy on Climate Change	Canada's National Implementation Strategy on Climate Change	

Subject	File Name	Document Title	Theme/s and notes (where indicated)
	Canada's First National Climate Change Business Plan	Canada's National Implementation Strategy on Climate Change	Government of Canada's response to climate change effects. The report includes actions to reduce risks associated with climate change as well as the costs and consequences in reducing emissions and adapting to a changing climate
Devon, county, UK		A Warm Response, Our Climate Change Challenge-Forward	Forward to Climate Change strategy report for Devon County
Scotland	Climate Change Mitigation Strategy for Scotland, Workshop Report	Climate Change Mitigation Strategy for Scotland, Workshop Report	

Subject	File Name	Document Title	Theme/s and notes (where indicated)
Brazil, South America and the Carribean	Climate Change and Sustainable Development: A Brazilian Perspective	Climate Change and Sustainable Development, A Brazilian Perspective	Discusses main issues and approaches required to build equitable regimes to address climate change under a Brazilian perspective
Brazil, South America and the Carribean	National Communication, Climate Change, Republic of Ecuador	National Communication, Climate Change, Republic of Ecuador, Climate Change	Represents Peruvian Govt's response to Climate Change mitigation and adaptation
Brazil, South America and the Carribean	UNDP, National Communication of Brazil to the UNFCCC	Second National Communication of Brazil to the UNFCCC	Discusses Vulnerability and adaptation issues, GHG inventory and removal/sequestration. Develops global circulation model for Brazil
Brazil, South America and the Carribean	Guyana Climate Change Action Plan	Guyana Climate Change Action Plan	Report is in response to the country's commitment to the UNFCCC in suggesting actions to addressing Climate Change problems
Brazil, South America and the Carribean	Peru Climate Change Strategy	Bridging Gaps in Dealing with Climate Change, the case of Peru	Aims to reduce impacts of Climate Change through integrated assessment of vulnerability and adaptation in vulnerable zones or sectors in Peru
WC SDF	1-3_cfgdtc_pages_1-50_web	Western Cape Provincial Spatial Development Framework, Final Report	Report describes WC Provincial Spatial Development Framework (WCPSDF) by first discussing its origins, i.e., national framework etc. normative issues, challenges facing the WC in natural resource, built environment and socio-economic patterns. Currents status of overarching policy and legislation among others are also discussed. Also presented are action plans required to carry out the objectives of the WCPSDF
WC SDF	4a_wc_pages_51-114_web	The Western Cape Province Today	Paper is part of the WCPSF and covers chapter four. Chpt 4 focuses on the present state of the natural systems in the province, e.g., climate, geology etc
WC SDF	4b_wc_pages_115-184_web	Built systems	This part of the report discusses settlements, growth potential and human need, transport, water supply infrastructure, sewerage, energy and telecom
WC SDF	4c_wc_pages_185-274_web	Socio-economic systems	Provincial demographics, growth trends, Human Development Index, investment, tourism etc are discussed in this component

Subject	File Name	Document Title	Theme/s and notes (where indicated)
WC SDF	5_currentstatusspatialplanning_pages_275_-_283_web	Current status of Spatial Development Planning in the Western Cape	This constitute chapter 5 of the WCPSDF
WC SDF	6_draft_comments_proposal_phase_pages_284_-_300_web	Summary of Comments to the Draft WCPSDF	Presents the conclusions of the various stakeholder engagements undertaken to solicit responses on the Draft WCPSDF
WC SDF	7_synthesis_pages_301-344_web	Synthesis of the Analyses	Attempts to synthesise the key findings covered in the report including the major themes - natural systems, socio-economic trends
WC SDF	8_vospa_pages_345-420	Vision, objectives, strategies, policies and action plans	The policies and their corresponding action plans are given in this part of the report
WC SDF	9_implementation_pages_421-428_web	Implementation	Indicates general plans required to ensure that action plans are implemented
WC SDF	10_conclusion_pages_429-435_web	Conclusions	Draws conclusions on technical components as well as stakeholder inputs and then makes a number of recommendations
WC SDF	11_annexures_pages_437-460_web	Annexures	Annexure contains the National Environmental Management Act, 107 of 1998 and the Development Facilitation Act Principles 67 of 1995
WC Economic Outlook 2006	chapter_3_final	3 Sectoral Growth and Employment Characteristics	
South Africa	National Climate Change Strategy for South Africa	Climate Change Response Strategy for South Africa	In addition to fulfilling South Africa's obligation under the UNFCCC regarding the Kyoto Protocol, the report also supports policies and principles mentioned in the Government's White Paper on integrated Pollution on Waste Management and other national policies relating to energy, agriculture and water
New Zealand	Climate Change, The New Zealand Response Strategy I	Climate Change, The New Zealand Response, New Zealand's first National Communication under the Framework Convention on Climate Change, Sept. 1994	Provides details of NZ's current emissions, policies and measures and projections of their impacts in reducing GHG effects as required by UNFCC
New Zealand	Climate Change, The New Zealand Response Strategy II	Climate Change, The New Zealand Response, New Zealand's Second National Communication under the Framework Convention on Climate Change, June 1997	Provides a mid-course report of New Zealand's progress towards meeting all her commitments under the UNFCCC
New Zealand	New Zealand, National Science Strategy Committee for Climate Change, Annual Report	National Science Strategy Committee Report on Climate Change, Annual Report 2000	Report comments on current state of climate change research, identifies gaps in our knowledge and make recommendations on future funding, research priorities and policy development

Subject	File Name	Document Title	Theme/s and notes (where indicated)
Climate Change Response Strategy and Action Plans/Case Studies	Brazil, India, Mexico and South Africa	Concerns about Climate Change Mitigation Projects: Summary of findings from Case Studies in Brazil, India, Mexico and South Africa	Summarizes studies for the 4 countries, Brazil, India, Mexico and South Africa. These countries are thought to have large GHG emissions and are also engaged in the debate on climate change projects under the Kyoto Protocol. The studies examine the current projects/programmes and are able to address eight technical concerns about joint implementation can be adequately addressed
Climate Change Response Strategy and Action Plans/Case Studies	Climate Change Mitigation Case Studies from Poland	Climate Change Mitigation, A Case Studies from Poland Oct. 1997	The case studies presented in the report are on (1) geothermal energy in Poland (2) building public awareness through a training project and (3) industrial restructuring as part of macro-economic reform
Climate Change Response Strategy and Action Plans/Case Studies	Climate Change Mitigation Case Studies from China	Climate Change Mitigation, A Case Studies from China, Oct. 1997	The report contain three case studies on: (1) China green lights programme (2) introducing Energy Conservatism in Ghana (3) Renewable Energy and Windpower development in China
Climate Change Response Strategy and Action Plans/Case Studies	Climate Change Mitigation Strategies for Kentucky		
Climate Change Response Strategy and Action Plans	China National Energy Strategy and Policy 2020	China, National Energy Strategy 2020, Sub-title 7: Global Climate Change: Challenges, Opportunities and Strategy faced by China	China's situation and concerns with regard to global Climate Change, primary emissions demand for China's middle class, addressing Climate Change within a sustainable development framework. Also discussed is China's long term framework strategy for dealing with Climate Change
Climate Change Response Strategy and Action Plans	Second Netherlands National Communication On Climate Change Policies	Second Netherlands National Communication On Climate Change Policies, prepared for conference of parties under the Framework on Climate Change	
Climate Change Response Strategy and Action Plans	Singapore National Climate Change Strategy Consultation Paper	Singapore National Climate Change Strategy, Consultation Paper	Presents a four-prong approach to intervention to lessen impacts of Climate Change, these were: vulnerability and adaptation, public awareness, mitigation and competency building
Climate Change Response Strategy and Action Plans	Climate Change Strategy Woking Borough Council	Think Globally, Act Locally, Climate Change Strategy, Woking Borough Council, 2005	Report sought to update Climate Change strategy adopted by the Council in 2002 in terms of sustainable initiatives the council has pursued since the strategy's inception in 2002 and the contributing to the targets outlined
Climate Change Response Strategy and Action Plans	Climate Change Mitigation in Developing Countries, Pew Research	Climate Change Mitigation in Developing Countries Brazil, China, India, Mexico, South Africa and Turkey	Climate change mitigation efforts are examined in the countries considered. The six case studies outlined in the report identify a broad range of mitigation activities and potentials for each of the countries examined in the report
	Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies	Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies	Book serves as an introduction to a wide range of methods that can be used to design assessment studies for climate change impacts and related adaptation strategies.
	What Does Climate Change Mean for Agric In Dev	What does climate change mean for agriculture in developing countries? A	Quite an academic piece. The commentators question whether adaptation will resolve any problems at all since there is so much uncertainty

Subject	File Name	Document Title	Theme/s and notes (where indicated)
	Countries	comment on Mendelsohn and Dinar (World Bank Research Observer, vol 19, no. 2, August 1999	with Climate Change scenarios relating to Climate Change impact on agriculture. They rather call for more work to reduce the uncertainties
Water literature	desalination	Fresh water resources, News, desalination freshens up	Suggest that new developments could make large-scale extraction of clean water a major force in the battle against global thirst
Water literature	Domestic Policy Frameworks for Adaptation in the Water Sector	Domestic Policy Framework for Adaptations in Climate Change in the Water Sector, Draft for Review, Agenda 2	Examines current water policy in the UK, US, Canada and Finland
Water literature	Economic Impacts of Extreme Events, Focus on freshwater floods	Economic Impacts on New Zealand of Climate Change related extreme events, Focus on freshwater floods, Report to the NZ CC Office	Presents outlines for estimating flood losses in New Zealand (article in the journal Science)
Water literature	Israel water	Seeking Sustainability, Israel's Evolving Water Management Policy	Paper discusses how through a trial and error process Israel has developed a more sustainable path for water management (article in the Journal of Science)
Water literature	pollutants	The Threats of micro-pollutants in aquatic water systems	Reviews 3 scientific challenges in addressing water-quality problems caused by micro-pollutants (article in the journal Science)
Water literature	water 1	Running out of water and time	News article. Suggest that geography, politics and war combine to make the Gaza Strip a case for water resource planners
Water literature	Water review	Global Hydrological Cycles and World Water Resources	Discusses the role of Climate Change in the rate of available renewable freshwater resources. Paper suggests that reducing current vulnerabilities will enable population deal with dwindling water resources
Vulnerability & Adaptation	Creating an Index of social Vulnerability to Climate Change for Africa	Creating an Index of social Vulnerability to Climate Change for Africa	Creates an index to assess the levels of social vulnerability to Climate Change induced changes variation in water availability and to allow for cross country comparisons in Africa
Vulnerability & Adaptation	Vulnerability and Adaptation to Climate Change, Concepts, Issues, Assessment Methods	Vulnerability and Adaptation to Climate Change, Concepts, Issues, Assessment Methods	Paper provides an overview of the state of adaptation issues in the context of climate vulnerability literature and climate negotiations
Vulnerability & Adaptation	GRIDS Background-Study-Final, Hamilton's Vulnerability to Climate Change	GRIDS Background-Study-Final, Hamilton's Vulnerability to Climate Change	Argues that Hamilton's vulnerability to Climate Change must be considered in the development of the Municipality. Water, Health, infrastructure are all said to be linked with the vulnerability network. The paper indicate that the vulnerabilities in the city were consistent with those highlighted in the literature about vulnerability to Climate Change
Vulnerability & Adaptation	Poverty and Climate Change, Reducing the Vulnerability of the poor through adaptation	Poverty and Climate Change, Reducing the Vulnerability of the poor through adaptation	Paper looks at Climate Change and the poor, adaptations lessons from past experience and the way forward

Subject	File Name	Document Title	Theme/s and notes (where indicated)
Vulnerability & Adaptation	Vulnerability, risk and adaptation, conceptual framework	Vulnerability, risk and adaptation, conceptual framework	Presents tentative conceptual framework for studies of vulnerability and adaptation to Climate Change applicable to a wide range of systems, contexts and hazards
WC Economic Outlook 2006	chapter_3_final	3 Sectoral Growth and Employment Characteristics	Explores the sectoral dynamics of the Western Cape
WC Economic Outlook 2006	Socio Econ Profiling chapter_5_final	5 Socio-economic profiling at the Local level	Provides a detailed socio-economic profiling of all 30 municipalities in the Western Cape Province. The profile identifies areas where the province can work on to achieve shared growth. The key risks and challenges that faces the province are also discussed
WC Economic Outlook 2006	chapter_4_final	4 Employment dynamics	Chapter presents an analysis of Western Cape labour market providing historical trends and projections
Risk Management	AppF_PNNL_CAPP	PNNL Risk Communication Assessment and Prioritisation	CAPP provides a risk assessment tool that can be applied to several environmental issues
Tourism	2003-08-DV-tourism poster	Climate Change and Tourism	One page flyer that considers the link between climate change and tourism
Tourism	Climate Change & Tourism final-report	Climate Change and Tourism	Proceedings of the 1st International Conference on Climate Change and the environment
Tourism	tourism_and_climate_change	Climate Change and Tourism, WWF Issue Paper	Measures aimed at lessening the impact of Climate Change effects due to tourism are discussed.
Sustainable development, ecosystems and climate change	ABA Sust Dev, Ecosystems and climate change newsletter July 2005		
Risk management	Applying Risk Analytic techniques to integrated assessment of climate policy benefits	Applying Risk Analytic Techniques to Integrated Assessment of Climate Policy Benefits	Using a risk-weighted marginal costs of climate damage, the paper shows that modest reductions in GHG can produce significant benefits in terms of risks avoided
Environmental management and climate change	Building resilience to Climate Change through adaptive Management of natural resources	Sustainable development, Ecosystems and Climate Change Committee Newsletter	A collection of articles on climate change-related issues - persistent organic pollutants, management of ocean ecosystems, using and abusing the earth's natural capital
Socio-economic	Census, Key Results		

Title	Theme/s and notes (where indicated)
Millennium Ecosystem Assessment: Ecosystems and Human Well-being-- A framework for assessment, 2003	Lays out approaches, assumptions, processes, and parameters that scientists are using in most extensive study of the state of the planet's health and its effects on human well-being
Department of Environmental Affairs and Development Planning, Sustainable Development Implementation Plan, Draft, 2 Sept. 2006, UCT Env. Evaluation Unit and Incite Sustainability	Seeks to provide a clear action plan for ensuring that principles of sustainable development are effectively embedded in the policies, strategies, programmes and projects of the Western Cape government
Draft Policy Paper, A Framework for Considering Market-Based Instruments to support environmental fiscal reform in South Africa, April 2006, National Treasury, Tax Policy Chief Directorate	The paper looks at reforms to revenue-raising instruments, particularly environment-related taxes and charges and their role in wider fiscal policy. It also considers reforms on the expenditure side
The Working for Water Programme, Annual Report 2001/2	
Benefiting the bereaved and the environment through dignified and affordable funerals	Eco Coffin's flyer
The Greater Hermanus Water Conservation Programme	Hand out
The *User-pays* Project for Conservation by Visitors to Nature Reserves	Looks at the effect on resource use by visitors to protected areas when Climate Change accommodation units are retrofitted with meters so that visitors pay for their own use of water and electricity
Growth Potential of Towns in the Western Cape (2004), Department of Environmental Affairs and Development Planning, Centre for Geographical Analysis, University of Stellenbosch	The report identifies growth criteria for urban development and measures and quantifies the growth performance of all rural towns in the Western Cape.
Microeconomic Development Strategy for the Western Cape, Research Papers 2005: Volume A, Department of Economic Development	The report contains sector/theme research papers, which provide more details on the different sectors/themes and can be read on its own or in conjunction with the Micro-economic Development Strategy Synthesis Report: Version I: July 2005 which places the research papers within a broader context. The sectors/themes covered are agriculture, fishing/aquaculture, clothing and textiles, metals and engineering, oil and gas, electronics, biotechnology, cultural industries, arts, culture and creative arts and film
Annual Performance Plan, Western Cape Department of Environmental Affairs and Development Planning	Paper discusses programme and sub-programme performance targets
Cape Town Energy Strategy, October 2003, Draft, City of Cape Town	Provides an assessment of the state of energy in Cape Town identifies numerous issues within the sector and these are prioritised based on the City's stated priority areas as well as national and international imperatives
Towards the Development of an integrated Energy Strategy for the Western Cape, *Summary Draft Status Quo and Gap Analysis,* June 2005	Discusses the importance of energy for Western Cape and the environment, energy and prosperity, moving to a sustainable energy system and towards an energy programme for the province

Title	Theme/s and notes (where indicated)
Towards a sustainable development implementation plan for the Western Cape, A Concept Paper on Sustainable Development, May 2005	Report first discusses a conceptual framework for sustainable development and the global and national policy context for sustainable development. The possible leadership role of Western Cape on sustainable development issue are also presented. Key elements for sustainable development plan for the Western Cape and the mainstreaming of sustainability into policy, planning and decision making are also examined
Microeconomic Development Strategy for the Western Cape, Research Papers 2005: Volume B, Department of Economic Development	The report contain sector/theme research papers, which provide more details on the different sectors/themes and can be read on its own or in connection with the Micro-economic Development Strategy Synthesis Report: Version I: July 2005 which places the research papers within a broader context. The sectors/themes covered are Financial Services, Call Centres/Business Process Outsourcing, Information and Communication Technology, Tourism, Energy and Transport. The rest were small micro and medium enterprises (SMMEs) and Human Resources Development (HRD)

Appendix 5: Adaptation and mitigation response options matrix

Introduction

In order to formulate response options for a climate change response strategy, sectors and resources vulnerable to climate change were identified. Stakeholder engagement and discussions enabled a rapid assessment of the key issues and priorities as perceived by experts in the related fields, as well as politicians, local authorities and strategy administrators, industry players and communities. A vast number (around 280) possible response options - both mitigation and adaptation - emerged from the research, stakeholder consultations and expert review processes and were used to populate the matrix. These options are grouped for ease of reference on a sectoral / systems basis.

The sectors and systems each underwent risk and vulnerability assessments which were informed by research and analysis in each cluster based on the application of a framework that examined political, economic, social, technological, legal and environmental indicators. This allowed an initial level of prioritization within sectors and systems, based on understanding of the sensitivities and adaptive capacities within each. A multi-criteria analysis approach (encompassing economic, social, environmental and .ease of implementation. criteria) was then applied to the extensive matrix. This process resulted in a prioritised list of 38 possible response options.

Prioritised list of options

Sector	Adaptation and mitigations response options
Agriculture	Secure reliable supply of fresh water for irrigation
Water	Impacts/ resilience water supply systems to extended drought.
Agriculture	Plant protection: control of fruit fly
Agriculture	Extension of weather station network
Energy/Air	Air Quality monitoring for early warning pollution episode
Agriculture	Identify, monitor and control pests and diseases using IPM
Water	Science-government dialogue
Water	Leak fixing and UAW
Water	Encourage efficiency increases through pricing strategies/awareness
Water	Research on efficiency of water use by agricultural sector
Water	Implement the ecological reserve
Water	Regularly produce and publish interpretations of climate projections
Biodiversity	Invasive alien species management
Water	Monitor and evaluate activities
Biodiversity	Fire management
Biodiversity	Set up protected area along gradients/corridors of altitude, rainfall etc.
Fisheries	Research and monitoring
Fisheries	Operation management procedures
Fisheries	Social impacts mitigation
Biodiversity	Rehabilitate river banks (fight floods)
Water	Risk assessment and infrastructure vulnerability
Water	Remove invasive alien plants (IAPs) from the riparian zones
Water	Focus on improving efficiencies of water use
Energy/Air	Energy efficiency standards/Alternate energy sources
Biodiversity	Create fund biodiversity from water
Tourism	Integrate climate risks into development infrastructure
Tourism	Research impacts of climate change on tourism demand and project growth
Energy/Air	Strengthen and extend Air Quality monitoring network and capacity for early warning
Energy/Air	Subsidised programme to displace paraffin and wood fuel burning in low cost areas
Energy/Air	Energy Efficiency (EE) standards; incentivise EE programmes; implement targets; Establish feed-in tariff structure
Energy/Air	Alternate energy supply options (wind / SWH/ Natural gas)

Transport	Public transport systems on cleaner fuels (LPG / LNG buses); Provide support to LPG taxi industry initiatives (Kulani Gas)
Built Environment	Integrate CC factors into infrastructure planning - link to IDPs; Maintain in public domain or establish strong PPPs
Built Environment	Establish robust building standards that incorporate CC and implement these
Built Environment	Integrate CC into development planning and approval processes
Built Environment	Map highly vulnerable areas; floodlines etc and implement development bans in highly vulnerable zones
Disaster Management	Review DM processes and integrate CC into planning
Livelihoods	Strengthen and focus socio-economic data; develop scenarios
Livelihoods	Factor livelihood issues into all aspects of CC planning

Built environment; coastal zone; disasters

Source	Sector	Response option
Literature	Built environment	Air conditioning
Status quo report	Built environment	Response strategies for vulnerable housing
Status quo report	Built environment	Housing material/design/structure alternatives
Status quo report	Built environment	Upgrade/improve maintenance stormwater/sewage
Status quo report	Built environment	Adherence 1:50 flood line
Status quo report	Built environment	Design and construction houses for heating and cooling
Public	Built environment	Environmental friendly housing for low income
Public	Built environment	Taxation
Public	Built environment	Incentives for building for adaptation
Public	Built environment	Take account high water mark
Public	Built environment	Tighten regulations
Literature	Coastal zone	Integrated coastal zone management
Literature	Coastal zone	Better coastal planning and zoning
Literature	Coastal zone	Legislation for coastal protection
Literature	Coastal zone	Research and monitoring coasts and coastal ecosystems
Literature	Coastal zone	Protection economic infrastructure
Literature	Coastal zone	Sea walls and beach reinforcement
Literature	Coastal zone	Protection and conservation of sea grass and littoral vegetation
Status quo report	Coastal zone	Development at estuaries setback to above 5m mean sea level (MSL)
Status quo report	Coastal zone	Estuarine management plans to include climate variability
Status quo report	Coastal zone	Estuarine Protected Areas
Status quo report	Coastal zone	Prevent overexploitation living marine resources
Status quo report	Coastal zone	Develop vulnerability atlas
Status quo report	Coastal zone	Shoreline Management Plan
Status quo report	Coastal zone	Design coastal protection/development/structures to compensate sea level rise
Public	Disasters	Insurance
Public	Disasters	Access to observational network
Public	Disasters	Devolution responsibility to local communities
Public	Disasters	Public education
Public	Disasters	Early warning systems
Public	Disasters	Resources to core institutions
Public	Disasters	Communication infrastructure
Public	Disasters	Human capacity
Literature	Disasters	Disaster relief
Status quo report	Disasters	Improve capacity Provincial Disaster Management Centres
Status quo report	Disasters	Improve capacity Metropolitan Disaster Management Centres

Agriculture options

Source	Sector	Response option
Expert opinion	Agriculture	Practices to reduce soil loss (erosion) and increase soil water retention on grain farms: no-till or conservation tillage, no-burn

Expert opinion	Agriculture	Conserve and improve soil health and water retention through biological farming systems, increase carbon content and microbial activity e.g. crop rotation, inter-cropping, mulching, cover crops, working in weeds
Expert opinion	Agriculture	Improve irrigation efficiency (demand), change to drip, fertigation
Expert opinion	Agriculture	Secure reliable supply of fresh water for irrigation (supply management), preserve groundwater (this must be unpacked by the water sector)
Expert opinion	Agriculture	Remove and control alien invasives to restore stream flow
Expert opinion	Agriculture	Introduce stricter measures and increase monitoring capacity to reduce pollution and salinisation of fresh water resources
Expert opinion	Agriculture	Develop suitable genotypes (drought-, heat- and pest-resistant cultivars) through local breeding
Expert opinion	Agriculture	Change the crop to something more suited to the new conditions, this includes developing new infrastructure, and developing markets e.g. indigenous plants, Mediterranean-type crops
Expert opinion	Agriculture	Identify, monitor and control pests and diseases (both existing and new) using IPM (Integrated Pest Management)
Expert opinion	Agriculture	Plant protection: control of fruit fly using national/regional sterile insect release programme
Expert opinion	Agriculture	Extension of weather station network co-ordinated and managed by a central agency, with regular accurate information and forecasts to farmers, early-warning systems
Expert opinion	Agriculture	Develop scientifically-based but suitably packaged information systems to help farmers with decision-making, collate various sources of expert knowledge
Expert opinion	Agriculture	Develop efficient extension service for better technology transfer and adoption of modern farming practices
Expert opinion	Agriculture	Better integrated land use planning and economic development using CC scenarios, climate topologies, resource base, and GIS-based crop census
Expert opinion	Agriculture	Maintain and develop research capacity locally, incl. Indigenous knowledge base
Expert opinion	Agriculture	Improve trade equity, market access, benefit from new opportunities in global context
Expert opinion	Agriculture	Garden Route: plant indigenous forests prevent soil erosion, fires, floods for whole region
Literature	Agriculture	different planting dates
Literature	Agriculture	increased use irrigation
Literature	Agriculture	increased use groundwater
Literature	Agriculture	adjustments to livestock management
Literature	Agriculture	Soil conservation techniques/erosion control
Literature	Agriculture	Different varieties
Literature	Agriculture	Crop diversification
Literature	Agriculture	Change quantity of land under cultivation
Literature	Agriculture	Change from crops to livestock
Literature	Agriculture	Change from farming to non-farming activity
Literature	Agriculture	Change use/application of fertilisers and chemicals
Literature	Agriculture	Increased use water conservation techniques
Literature	Agriculture	Tree planting
Literature	Agriculture	Use of weather derivatives
Literature	Agriculture	No adaptation
Literature	Agriculture	Shading/sheltering
Literature	Agriculture	Change growing season
Literature	Agriculture	Move sites
Literature	Agriculture	Change from livestock to crops
Literature	Agriculture	Change from non-farming to farming activity
Literature	Agriculture	Changed use capital and labour
Literature	Agriculture	Agrometeorological advice
Literature	Agriculture	Investment in irrigation technology
Literature	Agriculture	Insurance and risk sharing

Literature	Agriculture	Integrated resource management land and water
Literature	Agriculture	Education on water-saving practices and changes in crop choices
Literature	Agriculture	Indigenous knowledge and coping strategies
Literature	Agriculture	Agroforestry
Literature	Agriculture	Food storage
Literature	Agriculture	Dam construction
Literature	Agriculture	Desalination
Literature	Agriculture	Re-utilisation of water
Literature	Agriculture	Cease activities
Public	Agriculture	Land use planning incl. cc scenarios
Public	Agriculture	New crop varieties
Public	Agriculture	Environmental friendly farming
Public	Agriculture	Process and technologies to deal with cc
Public	Agriculture	Research
Public	Agriculture	Extension officers
Public	Agriculture	Land reform
Public	Agriculture	Crops that use less water
Literature	Agriculture	Introduce minimum tillage
Status quo report	Agriculture	Diversification of production and processing
Status quo report	Agriculture	Organic farming
Status quo report	Agriculture	Ploughing practices
Status quo report	Agriculture	Soil-moisture conservation practices

Water options

Source	Sector	Response option
Expert opinion	Water	Conduct risk assessments of floods to population nodes. Assess the vulnerability of infrastructure in each of these to damage or destruction by floods, for example, and invest in the appropriate improvement in coping capacity. This includes enforcing building codes and restricting occupancy in any way of flood-prone land. This approach has the greatest payoff in monetary terms in the short-term, as well as being compatible with a no-regrets policy, minimises environmental impacts and is probably highly cost-effective. A result is to avoid the consequences of declaring an area a disaster area after an extreme weather event.
Expert opinion	Water	Build understanding of the implications of climate change and set up a dialogue between science and government, at all levels of government. Focus on developing trust between the different levels of government, and the science, of climate change. Focus on implementing what is feasible, while avoiding hype and possibly exaggerated impacts of climate change outcomes. This creates good-will in government to fund adaptation projects and creates opportunities for a political payoff.
Expert opinion	Water	Focus on improving efficiencies of water use in both private and public sectors. In the public sector, fix leaks and hunt down unaccounted-for losses. Focus on .*excessive* water users and establish reasons for use level.
Expert opinion	Water	Remove invasive alien plants (IAPs) from the riparian zones (of which there is a vast amount in the Western Cape). Prioritise these on the basis of cost-effectiveness, in the short-term and in the future.
Expert opinion	Water	In the private sector, encourage efficiency increases through pricing strategies and awareness campaigns.
Expert opinion	Water	Encourage research on efficiency of water use by the agricultural sector and assist with technology transfer.
Expert opinion	Water	Implement the ecological reserves. Ensure that adaptations and growing water demand does not stress natural systems unnecessarily. Removal of IAPs can help achieve this, without re-allocating stresses to commercial and human needs.
Expert opinion	Water	Develop a body of knowledge regarding the impacts and resilience of the water supply systems, the agricultural sector and the ecological water users, to extended drought.

Expert opinion	Water	Regularly produce and publish interpretations of climate projected by season in advance, as well as interpretations of past season.s climate. By regularly undertaking this activity, build a stories and pictures, backed by data of climate in the Western Cape, how it is changing, and the impacts on all sectors of society.
Expert opinion	Water	Monitor and evaluate activities
Public	Water	pricing of water
Public	Water	import water intensive products
Public	Water	improve water distribution/supply and management
Public	Water	change way value water
Public	Water	recycle water
Public	Water	culture of zero tolerance on water misuse
Literature	Water	Conservation/protection water catchment areas
Literature	Water	Irrigation policies
Literature	Water	Flood controls
Literature	Water	Drought monitoring
Literature	Water	Protection groundwater resources
Literature	Water	Improved water supply - groundwater, desalination
Literature	Water	Modify reservoirs operating rules
Status quo report	Water	Manage water demand
Status quo report	Water	Equalisation - more dams
Status quo report	Water	Freshwater reserve determination
Status quo report	Water	Differential price structures
Status quo report	Water	Drip irrigation
Status quo report	Water	Integrate with National Water Resources Strategy
Status quo report	Water	Increased water supply
Status quo report	Water	Inter-basin transfers
Status quo report	Water	Modify catchment vegetation
Status quo report	Water	Control water pollution
Status quo report	Water	Raising dam walls
Status quo report	Water	Desalination
Status quo report	Water	Water demand management
Status quo report	Water	Reduction water services losses
Status quo report	Water	Re-use and recycling water
Status quo report	Water	Market mechanisms in allocation of water
Status quo report	Water	Contingency planning for drought
Status quo report	Water	Monitoring and forecasting floods and droughts
Status quo report	Water	Maintain options for new dam sites
Status quo report	Water	Reduction losses of agriculture

Biodiversity and tourism options

Source	Sector	Response option
Expert opinion	Biodiversity	Invasive alien species management
Expert opinion	Biodiversity	Fire management
Expert opinion	Biodiversity	Set up protected area along gradients (altitude, rainfall etc)/corridors
Expert opinion	Biodiversity	Rehabilitate river banks (fight floods)
Expert opinion	Biodiversity	Rebuild resilience
Expert opinion	Biodiversity	Create fund biodiversity from water
Expert opinion	Biodiversity	Seedbanks
Expert opinion	Biodiversity	Assessing floodlines
Expert opinion	Biodiversity	Values for biodiversity (e.g. for tourism, carbon storage)
Public	Biodiversity	Support to areas upholding biodiversity
Public	Biodiversity	Resources and planning to maintain health ecosystems
Status quo report	Biodiversity	Establish succulent Karoo protected areas
Status quo report	Biodiversity	Expansion of protected areas
Status quo report	Biodiversity	Unfenced corridors

Status quo report	Biodiversity	Reduce regulatory bureacracy regarding translocation
Status quo report	Biodiversity	Economic valuation of ecosystems services
Status quo report	Biodiversity	Protect assets against fires (firebreaks, resources, equipment)
Status quo report	Biodiversity	Removal/control flammable alien species
Status quo report	Biodiversity	Conservation and spatial planning/strategies
Status quo report	Biodiversity	Monitor change
Status quo report	Biodiversity	Translocation species
Status quo report	Biodiversity	Ex situ conservation
Public	Tourism	Research and analyse impact of CC on tourism
Public	Tourism	Promote carbon-neutral tourism

Air, transport, energy options

Source	Sector	Response option
Status quo report	Air quality	Waste disposal alternatives
Status quo report	Air quality	Cleaner technologies
Status quo report	Air quality	Enforce legislation
Status quo report	Air quality	Improve air pollution control capacity
Status quo report	Air quality	Develop air quality management system
Status quo report	Air quality	Early warning system on high pollution episodes
Expert opinion	Energy	Green energy
Expert opinion	Energy	Energy efficient standards/Alternative energy sources
Expert opinion	Transport	Biodiesel
Expert opinion	Transport	Fast tracking catalytic convertors
Expert opinion	Transport	Maintenance lower emissions, inspectation maintenance
Expert opinion	Transport	Scrapping old vehicles
Expert opinion	Transport	Mass transit, public transport systems
Public	Energy	Architectural design
Public	Energy	Reflective paint
Public	Energy	Energy efficiency standards
Public	Energy	Alternative energy
Public	Energy	Demand side management & conservation
Public	Energy	Penalties on import transport materials
Public	Energy	Legislate 'white goods' industry
Literature	Energy	Energy efficient lightning programmes
Literature	Energy	Cogeneration and thermal cascading
Literature	Energy	Fuel switching
Literature	Energy	New technologies and processes
Status quo report	Energy	Promote renewable energy opportunities
Literature	Transport	Energy efficiency improvements
Literature	Transport	Alternative energy sources
Status quo report	Transport	Public transport
Status quo report	Transport	Legislation to reduce exhaust emissions
Status quo report	Transport	Incentives car/fuel manufacturers improve efficiency/green technology
Status quo report	Transport	Holistic planning
Expert opinion	Energy	Air Quality: ambient monitoring for early warning pollution episodes

Fisheries options

Source	Sector	Response option
Expert opinion	Fisheries	Research and monitoring of marine environment and CC impacts
Expert opinion	Fisheries	Operation management procedures Build risk into the modelling
Expert opinion	Fisheries	Social impacts mitigation: research scenarios
Expert opinion	Fisheries	Alert/sensitise fisheries/communities to possible effects/impacts of Climate change on livelihood

Public	Fisheries	Global view on industry and stock levels
Public	Fisheries	Monitor and research fish stock
Status quo report	Fisheries	Exploitation at predicted stock levels (I.e. prevent over-exploitation)

Health, livelihoods, finance options

Source	Sector	Response option
Status quo report	Financial	Better shareholder activism
Status quo report	Financial	Individualise information to various industries
Status quo report	Financial	Inform carbon liabilities
Status quo report	Financial	Carbon tax
Project team	General	Monitoring
Project team	General	Extension officers
Project team	General	Communication
Project team	General	Research support
Project team	General	Data gathering and modelling
Public	General	Planning, Urban design, open space
Public	General	Planning to avoid crises management
Public	General	Training
Public	General	Raising awareness
Public	General	Education of media
Public	General	Improve link science and government decision-making
Public	General	Integration university departments
Public	General	Legislation to change behaviour
Public	General	Economic instruments (pricing, tax, incentives, disincentives, penalties, fines)
Public	General	Improve disaster management
Public	General	Externalities in account
Public	General	Process and technology
Public	General	Legislature
Public	General	Capacity to improve analysis
Status quo report	General	Integration climate change into planning strategies and frameworks (PGDS, PSDF, IDP, SDF, WSDP)
Public	Human	Health support health initiatives
Public	Human	Health awareness heat related stress
Public	Human	Health identify health risk factors
Literature	Human	Health Disease/vector surveillance and monitoring
Literature	Human	Health Improve environmental quality
Literature	Human	Health Changes urban and housing design
Literature	Human	Health Public health management reform
Literature	Human	Health Improved housing and living conditions
Literature	Human	Health Improved emergency response
Status quo report	Human	Health Holistic planning
Literature	Livelihoods	Domestic biogas digesters
Status quo report	Livelihoods	Basic needs grant
Status quo report	Livelihoods	Diversification strategies
Status quo report	Livelihoods	Integrate community concerns into water resources planning
Status quo report	Livelihoods	Comprehensive vulnerability assessment on regional scale
Status quo report	Livelihoods	Support adaptation at livelihood level
Status quo report	Livelihoods	Facilitating adaptation to annual climate variability
Status quo report	Livelihoods	Improved management of flooding and early warning
Status quo report	Livelihoods	Effective communication on extreme events
Status quo report	Livelihoods	Organised response operations
Status quo report	Livelihoods	Improved sanitation
Status quo report	Livelihoods	Increased capacity waste and storm water facilities
Status quo report	Livelihoods	Relocation high-risk sewage works

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