Climate Change

AND

the Agricultural Sector

IN

South Africa

Compiled by

I.B. Kgakatsi (Coordinator)
R.J. Sebola
R.O. Barnard (ARC-ISCW)
M.I. Motsepe
G. Morakile
S.M. Mugeri
B. Manyakanyaka

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DEPARTMENT OF AGRICULTURE

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Director General
Department of Agriculture
Private Bag X250
Pretoria
0001 South Africa

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Foreword and acknowledgement

The Working Group on Climate Change (WGCC) in the Department of Agriculture (DoA) was established a few years ago in order to address issues relating to climate change in the agricultural sector. The working committee, as coordinated by the directorate Agricultural Disaster Risk Management (ADRM), comprises the following directorates: Research and Technology Development (RTD), Water Use and Irrigation Development (WUID) and Land Use and Soil Management (LUSM) as well as the ARC. Since agriculture is one of the sectors most affected by the impacts of climate change, DoA has emphasized prevention, adaptation and mitigation strategies such as supporting risk management initiatives, research on large-scale epidemics and identifying hazards.

A discussion document on “Climate change and the agricultural sector in South Africa” was developed and presented at a DEXCO side committee: STC in 2005. Among other aspects it addressed adaptation and mitigation strategies for agriculture that were highlighted in the National Climate Change Response Strategy developed by DEAT. This is intended inter alia to support the policies and principles in the Government White Paper on Integrated Pollution and Waste Management, as well as other national policies including those relating to agriculture, energy and water. The National Climate Change Response Strategy for South Africa was designed to address issues that had been identified as priorities to deal with climate change in South Africa. DoA is represented in both the Government Committee on Climate Change (GCCC) and National Committee on Climate Change (NCCC), coordinated by Department of Environmental Affairs and Tourism (DEAT).

The WGCC as compilers of this document would like to thank all the people who contributed in the compilation, especially I.B. Kgakatsi (coordinator), R.J. Sebola, Prof R.O. Barnard (ARC), M.I. Motsepe, Dr G. Morakile, S.M. Mugeri and B. Manyakanyaka. The compilers also wish to thank the organizers of the Climate Change workshop hosted by agriculture early in February 2006, research and academic institutions and all the people who participated and gave valuable inputs into the climate change discussion document.

It should be regarded as a living document and it is trusted that it will form the basis of discussions and actions related to the agricultural sector in South Africa.

Department of Agriculture (DoA), Directorate Agricultural Disaster Risk Management

PRETORIA
2007

1. BACKGROUND

This document, prepared by the Department of Agriculture (DoA), was initiated from the discussions on South Africa's Initial National Communication under the United Nations Framework Convention on Climate Change (UNFCCC) and the South African National Climate Change Response Strategy. It is an attempt at bringing together concepts relating to climate change and the possible effects that these can have on the agricultural sector in South Africa. It is envisaged that this will serve to inform decision makers in current perceptions and follow-up action necessary to address the risks and challenges relating to climate change and agriculture.

1.1 Climate change

Climate change is commonly regarded as an increase in the concentration of so-called greenhouse gases (GHGs). A number of gases that normally occur in the atmosphere in relatively small quantities, such as water vapour, carbon dioxide (CO_2), methane (CH_4), nitrous oxides (No_xs) and chlorofluoro carbons (CFCs) allow shortwave solar radiation to reach the earth's surface, however, tend to absorb the long-wave radiation emitted from the earth's surface.

This absorption leads to warming of the lower atmosphere, creating the temperatures we experience. Without this, the earth would be considerably colder than is currently the case.

1.2 The greenhouse effect

Gases such as carbon dioxide and methane are referred to as "greenhouse gases", as they play a role in regulation of temperature in the same manner as that taking place in greenhouses. Normal fluctuations of these gases occur and this does not have any lasting effect on climate. Climate as such is characterised by fluctuations or cycles that occur naturally. Over the last 100 to 200 years, following the industrial revolution, large increases in GHG emissions have occurred, mainly through anthropogenic (human-induced) activities. It is estimated that 50 % of the increase in concentrations of GHGs can be ascribed to the use of fossil fuel (coal, oil), 20 % to the chemical industries and the rest to agriculture (including deforestation). These increases have enhanced the greenhouse effect. While the climate of the world displays natural variation, the preponderance of scientists believe that the ever-rising quantities of greenhouse gases is overshadowing this natural variation and causing serious climate change.

1.3 Implications

The climate system is extremely complex and relatively poorly understood, especially regarding its extent, timing and impact. What is currently known, however, points to many dramatic negative effects that climate change can have on food security, economic activity, human health, water resources, extreme weather events, low-lying areas and infrastructure. The effects are not necessarily always negative, however, and positive spin-offs need to be identified and maximised. It is important that these implications be understood and interrogated for both so-called first and second economies in the agricultural sector in South Africa, to ensure sustainable development.

2. POTENTIAL EFFECTS OF CLIMATE CHANGE ON AGRICULTURE

The South African Country Study based on one of the Hadley Centre in the UK (HADCM2) scenarios predicts a decrease in South Africa's rainfall over most of the country—the summer rainfall region by 15 % and winter rainfall by 25 % by 2050. Temperature will increase between 2.5 and 3 °C. Runoff into main rivers is likely to be reduced, e.g. an expected decrease in outflow from the Orange River of 12 to 16 %. There will be a possible increase in frequency of fires, saltation problems will occur and there will be an increased demand for irrigation. The arid interior and moister north-eastern regions of South Africa are likely to be subjected to elevated evapotranspiration rates, increased stress and more frequent flood events, whereas the south-western regions of the country are likely to experience increased early winter onset and lower rainfall. The areas currently classified as water-stressed are likely to increase, while food shortages might become more frequent and widespread.

Much of the western area suitable for maize production might become unsuitable as a result of the decreased rainfall and soil moisture. The impact of the CO_2 fertilisation effect (increased growth through increased photosynthesis) might assist with the yield, only in some areas, however. The estimations are that with the CO_2 fertilisation effect the minimum loss of maize production will be R46 million and, without the effect, R681 million.

Significant decrease in river flow in the southern and western catchments is predicted, leading to shrinkage of areas amenable to the country's biomes to about half of their current extent, with huge losses in biodiversity. The largest losses will occur in the western parts of SA. Modelling predicts that the *Proteaceae* family will be in danger of becoming extinct. This can result in an economic disaster as harvesting of this biome makes a substantial contribution to the national economy. Other natural ecosystems might also be in danger.

South Africa is particularly vulnerable to climate variability, as farming depends greatly on the quality of the rainy season. Increased droughts in combination with higher temperatures could have a serious impact on the availability of food. The impact of drought extends beyond food shortages and negatively affects national economies and reduces the country's ability to produce export crops and generate foreign currency. Water is a critical element of national welfare and productivity because of the role it plays in many forms of consumptive use, ranging from drinking, sanitation, recreation, irrigation, power generation, transportation and many other uses. In the next two to three decades, SA will likely fall below the benchmark of 1 000 m^3 of water per year per person. Marginal lands will be more prone to reduced yields owing to increased frequency of crop failure and land degradation. Annual crop production is negatively affected by regular dry seasons.

The annual crop yield can be considerably higher if crop losses owing to low and irregular rainfall can be minimised. Drought tolerant crops will have the potential to enhance the efficiency of crop production by increasing cultivation and yields in marginal areas. The principle of "more crop per drop" needs to be maximised and all forms of increasing rainfall efficiency, such as by water harvesting, should be adopted.

Possible negative effects on veld cover and composition and the influence that this could have on carrying capacity for livestock and game also have to be kept in mind.

3. INTERNATIONAL CONCERN

3.1 The United Nations process

The first United Nations Summit on Sustainable Development was held in Rio de Janeiro in 1992. The links between environment and development, based on deep concern that development often had an adverse effect on the environment and did little to alleviate poverty, were the focus of discussions.

At the Rio Summit, the United Nations Framework Convention on Climate Change (UNFCCC) was signed, entering into force on 21 March 1994. The Convention recognised the accelerated change in Earth's climate over the last 200 years and that the cause of this is an increase in concentrations of greenhouse gases in the atmosphere, causing a warming of the Earth's surface. Most of these increases emanate from the industrialised nations and their largely fossil-fuel energy-based economies that can be traced back to the Industrial Revolution.

The main objective of the UNFCCC was to stabilise atmospheric concentrations of greenhouse gases caused by human activities and thereby counter dangerous climate changes. In order to attempt to achieve this, the third Conference of the Parties, (COP 3) to the UNFCCC, held in Kyoto, Japan in December 1997, adopted the "Kyoto Protocol", which obliges industrialised countries to reduce the greenhouse gas emissions by an average of 5,2 % compared to 1990 levels, by the first commitment period between 2008 and 2012.

Since the Convention entered into force in 1994, annual meetings of the Conference of Parties (COPs) have taken place, together with numerous specialised workshops and meetings on specific matters. The

Kyoto Protocol attempts to commit industrialised countries to achieve quantified targets for decreasing their emissions of greenhouse gases and came into force on 16 February 2005.

The Intergovernmental Panel on Climate Change (IPCC), that has done tremendous work on the science of climate change, has estimated that greenhouse gas reductions have to be at least 60 % by the end of the 21st Century to avoid dangerous climate change.

Under the Buenos Aires Plan of Action (BAPA), adopted at the fourth COP in 1998, parties set a two-year deadline for strengthening implementation of the UNFCCC and preparing for future entry into force of the Kyoto Protocol.

Subsequently, COP 5 was held in Bonn in 1999 and COP 6 in The Hague, The Netherlands in November 2000.

Despite intensive negotiations and effort by the President of the COP 6, Jan Pronk of The Netherlands, both technically and politically, negotiations could not achieve an agreement, with financial issues, supplementarity in the use of mechanisms, compliance and Land Use, Land-use Change and Forestry (LULUCF) proving to be extremely difficult issues. It was finally announced that the delegates had failed to reach agreement, agreed to suspend COP 6, but expressed willingness to resume work in 2001.

COP 6-bis, or part II, was held in Bonn between 16 and 27 July 2001. In the interim the United States declared its opposition to the protocol and several political initiatives were made to maintain support for the protocol and its entry into force by 2002. In both technical and political negotiations, a large measure of progress was made, resulting in adoption of the “Bonn Agreement”. Although decisions could be adopted on several key issues, all the work on mechanisms, compliance and LULUCF could not be completed. All decisions were therefore forwarded to COP 7, held in Marrakesh, Morocco from 29 October to 9 November 2001, where delegates attempted to conclude their negotiations and complete tasks previously left unfinished.

The Marrakesh Accords were eventually agreed on following extensive negotiations, with key features including consideration of LULUCF principles and limited banking of units generated by sinks under the Clean Development Mechanisms (CDM). At the close a package deal was reached on LULUCF, mechanisms, Protocol Articles 5, 7 and 8 and input into the planned World Summit on Sustainable Development (WSSD).

From 26 August to 4 September 2002, the WSSD was held in Johannesburg, South Africa. The WSSD adopted text identifying the UNFCCC as the “key instrument” for addressing climate change and emphasising the importance of developing cleaner technologies in the energy sector.

The Johannesburg Plan of Implementation (JPOI) also referred to timely ratification of the Protocol by those states who had not done so yet. Further agreed identified actions included to address climate change, such as providing technical and financial assistance to developing countries.

During COP 8 (held from 23 October to 1 November 2002, in New Delhi, India) the Delhi Declaration was made that reaffirmed development and poverty eradication as main priorities in developing countries, while recognising countries’ common but differentiated responsibilities in national development priority and circumstances in the implementation of UNFCCC commitments. Subsequently COP 9 was held in Milan in 2003, COP 10 in Buenos Aires in 2004 and COP 11 in Montreal, Canada in 2005. At the latter the questions of mitigation and adaptation were hotly debated and more than 40 decisions were adopted to strengthen global efforts to combat climate change. The Kyoto Protocol will be implemented, dialogue about future action beyond the first commitment period of 2008 to 2012 commenced, a five-year programme of work on impact, vulnerability and adaptation to climate change adopted and the future work of the Convention and Protocol discussed.

3.2 The Intergovernmental Panel on Climate Change (IPCC)

The Intergovernmental Panel on Climate Change (IPCC) is an independent body that was founded under the auspices of the World Meteorological Organisation (WMO) and the United Nations Environment

Programme (UNEP) in 1988. It assesses the scientific literature and provides vital scientific information to the climate change process. The current structure of the IPCC consists of three Working Groups: Working Group I addresses the science of climate change; Working Group II deals with impact, vulnerability and adaptation; and Working Group III with mitigation.

The IPCC is best known for its comprehensive assessment reports, incorporating summaries for policymakers from all three Working Groups, which are widely recognised as the most credible sources of information on climate change. The First Assessment Report in 1990 assisted in launching negotiations on the Convention. The 1995 Second Assessment Report, in particular its statement that "the balance of evidence suggests… a discernible human influence on global climate", stimulated many governments into intensifying negotiations on what would become the Kyoto Protocol. The Third Assessment Report (TAR), released in May 2001, confirmed the findings of the Second Assessment Report, providing new and stronger evidence of a warming world. A Fourth Assessment Report is currently being compiled and reviewed. When it becomes available in 2007 it will provide comprehensive and up-to-date information on climate change, its causes, impact and possible response measures based on the latest scientific, technical and socio-economic literature. Assessment Report 4 (AR4) will consist of three working groups' contributions and a synthesis report, the latter due by mid-November 2007.

In the IPCC Special Report on Land Use, Land-use Change and Forestry (LULUCF, 2000),) the importance of evaluating aspects such as carbon flows between different pools and how carbon stocks change with afforestation, reforestation and deforestation and other land-use activities has to be evaluated objectively. From this it is clear that some quantitative evaluation of current stocks of carbon requires attention so that background values can be determined. These are necessary to be able to validate and measure changes over time. All IPCC publications are available at http://www.ipcc.ch/.

3.3 Carbon sequestration in general

In broad terms, carbon sequestration is the process of capturing CO_2 emissions, which would otherwise be released into the atmosphere and permanently storing them in geologic formations. These include oil and gas reservoirs, unmineable coal seams and deep saline reservoirs, or deep in the oceans (Carbon Sequestration Forum). Carbon sequestration can also be done terrestrially in forests, crop and rangelands, and in wetlands. Terrestrial sequestration is considered an indirect sequestration, whereby ecosystems (natural and agricultural) are maintained, enhanced or manipulated to increase carbon storage in excess of current levels.

Enhancing the natural processes that remove CO_2 from the atmosphere is considered to be one of the most cost-effective means of reducing atmospheric levels of CO_2. The potential for carbon sequestration by the terrestrial biosphere is considerable and many moves have been made to optimise this, while considering all the social, economic and environmental implications that this might have.

3.4 Sinks in the CDM

The Kyoto Protocol makes provision for three mechanisms—joint implementation, the clean development mechanism (CDM) and emissions trading that are designed to increase the cost-effectiveness of climate change mitigation by making ways available to parties to cut emissions, or enhance the use of carbon "sinks", more economically in foreign countries than at home.

Although the cost of reducing emissions or enhancing removals differs largely among regions, the effect on the global atmosphere is the same, no matter where the positive action is taken. Joint implementation is restricted to so-called Annex I parties (more developed countries) for trading among themselves under certain conditions.

The CDM is expected to generate investment in developing countries, especially from the private sector, enhance the transfer of environmentally friendly technologies and promote sustainable development in general. The rules formulated in the Marrackech Accords (COP 7, 2001) focus specifically on projects that reduce emissions. However, in a compromise decision, defined LULUCF activities are permitted.

These are afforestation and reforestation projects (sinks in the CDM) for the first commitment period, from 2008 to 2012.

It is difficult to estimate emissions and removals from the land use, land-use change and forestry (LULUCF) sector. The following rules have been negotiated for this sector:

- A set of principles to guide activities
- A list of eligible activities
- Common definitions
- A capping system (limiting amounts)
- Further development of inventory methods.

It is hoped that, with this approach, actual quantifiable removal of GHGs will be achieved through LULUCF activities, making a meaningful contribution to mitigating carbon dioxide emissions.

3.5 Carbon sequestration in the biosphere

Most of the attention at the climate change negotiations has been focused on forestry activities. This is because of their inclusion in the first commitment period. There is probably a two-fold reason why forests have in general received major attention: forestry activities are in most cases handled in association with environmental departments and ministries and the destruction of forests is a both dramatic and emotional issue for most people. In the broader sense of carbon sequestration in the biosphere, however, there are a number of other sinks that warrant consideration. Croplands, wetlands and pastures, in addition to forests, play major roles in sequestering carbon. If these are managed unsustainably, or destroyed, they emit carbon dioxide and other GHGs. If they are managed sustainably, however, they remove potentially large amounts of carbon dioxide from the atmosphere, storing it in biomass, soil and products. Practices such as afforestation, reforestation, sustainable forest management, conservation agriculture and the replacement of fossil fuel with biofuels all contribute to climate change mitigation and the responsible and sustainable utilisation of the natural resources

During side events at the climate change negotiations, increasing attention is being paid to many of these alternatives, as these may become permissible during commitment periods after 2012, under the Kyoto Protocol, emphasising the importance of maximising all efforts to sequester carbon.

Accurately measuring changes in carbon stock is very important to lending credibility to accounting of changes. In the case of some components, this is relatively easy in that the quantities are predictable and concentrations remain relatively constant. This lends itself to suitable modelling. Cases in point are aboveground biomass, belowground biomass and wood products and, to a great extent, litter. The fifth component is soil organic matter, which is considerably more dynamic and difficult to quantify and therefore to model.

The importance, however, of managing soil organic carbon in a sustainable manner has many advantages apart from carbon sequestration alone. These include combating desertification (CCD) and increasing biodiversity (CBD).

4. SOUTH AFRICAN INVOLVEMENT

As a result of the political isolation of South Africa up to the early 1990s, there was no official participation in the Earth Summit in Rio in 1992. By the time the UNFCCC had entered into force in 1994, however, South Africa had become involved in the climate change debate and activities.

With the national Department of Environmental Affairs and Tourism (DEAT) being the country's focal point for environmental conventions, DEAT has taken the initiative in coordinating actions and ensuring compliance with international obligations relating to climate change. The South African Government ratified the UNFCCC in August 1997.

After it was recognised that the commitments under the UNFCCC were inadequate for achieving its ultimate objectives, the Kyoto Protocol was adopted in 1997, after protracted international negotiations. South Africa acceded to the Kyoto Protocol in July 2002.

4.1 Requirements of the UNFCCC

Article 12 of the Convention requires parties to prepare an initial National Communication to which South Africa complied in 2003. In addition, detailed South African Country Studies reports have been compiled on a sectoral basis. From this work, together with information generated from the IPCC Third Assessment Report, DEAT, in consultation with other government departments and stakeholders, has developed a national climate change response strategy. The latter has only recently been approved by Cabinet and will be reviewed on a regular basis, empowering government committal to this important subject. It also places climate change on the agendas of all government departments.

4.2 South Africa's Initial National Communication

The Initial National Communication was prepared in accordance with Article 12 of the Convention and reported on the national circumstances; the national inventories of GHGs for 1990 and 1994; South Africa's vulnerability to climate change and its potential to adapt; the systematic observation and research undertaken in this field; education, training and public awareness programmes required; projections and policies made and measures taken; mitigation options and possibilities for adaptation and a preliminary needs assessment. For further information visit http://www.environment.gov.za.

4.3 National Climate Change Response Strategy for South Africa

This strategy took a relatively long time to develop, largely because of the value attached by DEAT to comprehensive consultation and buy-in by a wide range of stakeholders. The current document was released in September 2004, following Cabinet approval.

The main objective of the strategy is to support current government policy on related matters. This includes the National Environment Management Act (NEMA) of 1998, the Government White Paper on Integrated Pollution and Waste Management as well as on other national policies relating to energy water and agriculture. Regarding agriculture, the following are especially relevant:

- Integrated Food Security and Nutrition Programme
- Sustainable Utilisation of Agricultural Resources (SUAR) Bill to replace the Conservation of Agricultural Resources Act (Act No. 43 of 1983)
- Agricultural Water Management as related to the White Paper on a National Water Policy for South Africa, 1997 (and the imminent National Water Resource Strategy)
- Communal Land Rights Act (CLARA) (2002)
- Farmer Settlement Programme
- Comprehensive Agricultural Support Programme (CASP)
- Agricultural Black Economic Empowerment (AgriBEE) Programme,
  World Overview of Conservation Approaches and Technologies (WOCAT), Land Degradation Assessment in Drylands (LADA) and LandCare programmes.

Because climate change has so many ramifications, it is important that it be centre-staged in all developmental agendas.

4.4 WSSD

The World Summit on Sustainable Development, held in Johannesburg in 2002, firmly established the importance of the trilogy of social, economic and environmental dimensions in development. Its plan of implementation, the JPOI, highlights specific actions to ensure progress, including mitigation and adaptation relating to climate change. The Department of Agriculture (DoA) carefully analysed this document and circulated it to all directorates in DoA for comment and implementation.

On the second anniversary of the WSSD (WSSD+2), a dedicated high-level event was held at the same venue. Government departments were afforded the opportunity of hosting concurrent workshops and DoA presented a highly successful session, showcasing what the agricultural sector had achieved in the preceding two years. The highlights of this were presented at a concluding ministerial plenary session. A side-event on climate change was hosted by DEAT and DoA made a presentation at this event.

4.5 Synergy between environmental conventions

At international forums, such as negotiations on the Convention on Biodiversity (CBD), the Convention to Combat Desertification (CCD), the United Nations Framework Convention on Climate Change (UNFCCC) and the ongoing Commission on Sustainable Development (CSD) process, the synergies between the environmental conventions are being increasingly debated. This applies on a broad front, especially so when biological carbon sequestration is considered. The increase in soil organic carbon and its stabilising effect on physical, chemical and biological soil properties plays a huge role in achieving the social, economic and environmental goals of these and other conventions and treaties.

4.6 NCCC and GCCC

In order to assist DEAT in its mandate regarding the UNFCCC, the National Committee on Climate Change (NCCC) was established to act as an advisory body to the Minister of Environmental Affairs and Tourism.

Representatives from relevant government departments, as well as representatives from business and industry, mining, labour, community-based organisations and non-governmental organisations constitute the NCCC. The NCCC currently functions well, with frank and honest debate about the many contentious issues involved.

More recently it was regarded as advisable to establish a Governmental Committee on Climate Change (GCCC), to allow government representatives to caucus internally and present a more united front. Problems currently encountered relate to committal and continuity, both of which are essential to ensure more profound undertaking of the issues involved. DoA has played a visible and valuable role and will hopefully continue to do so.

In both of these committees specific tasks have been assigned to ad-hoc subcommittees, which has increased their efficiency.

5. MITIGATION, VULNERABILITY AND ADAPTATION

5.1 Introduction

Contributions towards reducing the levels of anthropogenic GHG production have to be encouraged actively. This implies innovative alternatives in a fossil fuel-based economy. At the same time adaptation strategies have to be developed and applied, in order to deal with the vagaries of climatic variation and the negative impact of severe weather events on both the first, but especially the second, economies. These should be informed by vulnerability assessments and a comprehensive vulnerability audit for agriculture needs to be conducted.

It is, above all, the poorer population groups in developing countries that will be the most adversely affected by climate change. They suffer most from the impacts of climate change, as they are mostly directly dependent on the natural environment and agriculture for their survival. The ongoing process of climate change will impact both. Owing to poverty, lack of education and poor infrastructure, there is little chance of switching to other sources of income. This is why the three pillars of sustainability are so important: people, prosperity and the planet.

5.2 Implications for agriculture

While the main crop-growing areas will remain the same, changes in crops and cultivars are likely, with heat tolerance and water use efficiency paramount. Disease and insect distribution will vary, affecting both plants and animals.

Handling the vagaries of climatic variation and positioning DoA to maximise both opportunities as well as dealing with the negative impacts of severe weather events and climate change will be the challenges of the future.

There has been much debate on both mitigation and adaptation possibilities and this will doubtlessly continue unabated. As mitigation is largely concerned with innovative ways of reducing emissions and adaptation with ways of dealing with changed or changing conditions, the main focus in agriculture will be on the latter, though not excluding the former.

Reducing GHG emissions through cleaner technology is the challenge on the one hand, however, developing alternative strategies for adapting to the negative effects of climate change is equally opportune and appropriate, especially for poorer communities and the second economy.

6. RECOMMENDED ACTION BY DOA

6.1 Proposed Departmental Working Group on Climate Change

It is recommended that a departmental Working Group on Climate Change be formed, with clear terms of reference. These would include regular meetings to discuss and address all matters relating to climate change, identification of priority areas for attention and procuring of funding for appropriate research and awareness raising among all stakeholders. Active involvement in other forums addressing climate change would also be involved, with creation and maintenance of corporate memory, continuity and succession planning in place.

This working group should develop these terms of reference (TOR) to be realistic, attainable and relevant.

The members of the Working Group should consist of a core team from at least the Directorates of ADRM (Chair), RTD, LUSM and WUID, as well as the ARC, preferably at senior management level. Alternates from each directorate should also be identified to ensure continuity. It would be ideal if staff could be dedicated to this important group and could be involved in other activities such as the GCCC and NCCC.

Other directorates at DoA, such as those dealing with plant and animal production systems, farmer settlement, food security and resource economics should also be involved, as appropriate, while representation from other state departments such as DEAT, Department of Water Affairs and Forestry (DWAF) and Department of Minerals and Energy (DME), could be considered. Core members of the Working Group should be actively involved in both the NCCC and GCCC.

6.2 Proposed plan of action

Through its current involvement in climate change activities, DoA is playing an important and proactive role in this matter. It is considered vital, however, that this impetus be maintained through active participation in local activities and governmental initiatives as well as in international negotiations and events.

In this regard it is recommended that:

- DoA continues to support the negotiating team coordinated by DEAT, as appropriate, with especially LULUCF expertise to future meetings.
- DoA maintains its prominent role on the National Committee on Climate Change (NCCC) and the GCCC to ensure the rightful, central place of agriculture in the climate change debate (principal and alternate delegates have to be confirmed; continuity is considered essential).
- The importance of social, economic and environmental issues in sustainable development be adequately recognised and addressed.
- Emerging international funding opportunities for technology transfer and capacity building be optimised in order to institutionalise and publicise the concepts of climate change, carbon sequestration and carbon trading.

- Baseline information, in preparation for carbon accounting, be established.
- Initiatives to improve strategies to anticipate, mitigate and adapt to climate change be encouraged, including through funding appropriate projects and identification of international funding opportunities.
- The synergies between Rio Conventions, especially the CCD, the CBD and the UNFCCC, which are receiving increasing international attention, be debated locally, especially by DoA personnel involved. Some form of joint committee/working group should also be considered.
- The implications of climate change in sustainable development be explicitly considered in actions relating to the NEPAD, SADC, the JPOI and departmental programmes.
- Active involvement in initiatives such as the SA Strategy for Sustainable Development be ensured.
- An awareness campaign/s be considered and initiated as appropriate, with DoA, provincial departments of agriculture (PDAs), the ARC, organised agriculture, other stakeholders, the general public and the youth. This would include general information, technical aspects, the implications of carbon trading and answering the question: “What can I/we do?”
- All opportunities for promoting terrestrial carbon sequestration (through photosynthesis) be utilised, including UNFCCC negotiations, side-events and corridor lobbying for the second commitment period. Actions include croplands, grazing lands, no till, soil cover, conservation farming and the use of biodiesel.
- The activities and actions of DoA are designed to contribute positively and proactively to combating the negative effects of climate change and to sustainable development with all its dimensions. This will include current actions such as issuing of early warning information and seasonal forecasts by ADRM and any innovative new approaches.
- A sectoral workshop be organised *inter alia* to discuss the draft discussion document and the recommendations contained therein.
- Prepare, develop and coordinate plans/research programmes to address the pertinent climate change issues affecting agriculture.

7. CURRENT INITIATIVES RELATING TO CLIMATE CHANGE IMPLICATIONS FOR SOUTH AFRICAN AGRICULTURE

7.1 Introduction

Although it is beyond the scope of a report such as the current one to attempt a comprehensive survey, it was nevertheless considered advisable to indicate what initiatives are currently topical, or the work that has been conducted in the past, or is planned for the future.

A comprehensive survey of climate change research in South Africa to date was presented by M.P. de Wit of Environmentek, CSIR, at a Forum for Economics and Environment (FEE) Symposium on Global Climate Change held in Pretoria in October 2000.This serves as valuable reference material on earlier work.

The three groups of participants in the climate change scenario on agriculture in South Africa are: universities, parastatals and others.

7.2 Universities

7.2.1 University of KwaZulu-Natal, Pietermaritzburg: School of Bioresources Engineering and Environmental Hydrology (BEEH)

During 1998 to 2000 an evaluation of potential impact of GHG-directed climate change on agriculture in South Africa was funded through the U.S. Country Studies project. Potential changes in maize production were assessed, using the CERES-maize model. Other work relating to impact on agriculture was also undertaken, including changes in crop yield, shifts in agricultural belts and changes in life cycles of selected pests.

Current activities include climate database development/refinement, through Water Research Commission (WRC) funding, regional climate model scenarios of climate change over South Africa, climate change detection studies, assessment of agro-ecosystem sustainability over South Africa and catchment case studies.

A more comprehensive exposition is attached as Appendix 3.

Future work is likely to include the use of the ACRU Agrohydrological Modelling System, refined gridded temperature and rainfall databases and the application of more complex crop growth models.

7.2.2 University of Pretoria, Pretoria

- Centre for Environmental Economics and Policy in South Africa (CEEPA)

  The CEEPA, University of Pretoria is involved in two major projects in Africa on vulnerability, impact and adaptation of agro-ecological systems to climate change. Details are provided in Appendix 4.
- Department of Geography

  Modelling based on history and future projections.

7.2.3 University of Cape Town, Cape Town

- Department of Environmental and Geographical Sciences

  Work on methodologies for developing regional climate change scenarios from more general circulation models.
- Energy and Development Research Centre

  Although their work concentrates on energy, a number of issues also impact on agriculture.

7.2.4 University of the Witwatersrand, Johannesburg

- School of Geography, Archaeology and Environmental Studies

  Department of Geography: Sustainability issues.

7.2.5 University of Zululand

Oceanographical and climate systems modelling.

7.2.6 University of Stellenbosch

- Department of Soil Science

  Work on carbon sequestration and carbon dynamics in different ecosystems and agricultural practices.

7.2.7 University of the Free State, Bloemfontein

Comprehensive investigations on soil carbon, nitrogen and sulphur dynamics and fluxes under different soil, climatic and cultivation conditions.

7.3 Parastatals

7.3.1 CSIR, Environmentek

This group has been involved in GHG issues and climate change over a long period, including the GHG inventory, adaptation studies, mitigation and technical inputs into IPCC studies and assessment reports.

7.3.2 South African National Biodiversity Institute (SANBI) previously NBI

SANBI has done valuable work and published extensively on the effects of elevated CO_2, changes in water availability and altered incidents of frost occurrence on the indigenous flora and vegetation of southern Africa.

Actively involved in climate change activities, including the South African Scientific Committee on Global Change and several international committees.

7.3.3 South African Weather Services (SAWS)

Contributions in the form of seasonal forecasts that can influence adaptation strategies in agriculture.

7.3.4 Agricultural Research Council (ARC)

The ARC, through its 13 institutes, has contributed in a number of ways to climate change science and implications. As the research arm of DoA, it has been, and should continue to be, proactively involved in the emerging climate change programme of the department.

The ARC institutes were requested to indicate their involvement in climate change- related activities. As valuable information is captured in these submissions, they are attached as Appendix 2.

7.3.5 Human Sciences Research Council (HSRC)

With poverty reduction as the unifying, linking theme, the HSRC's programme Integrated Rural and Regional Development's objectives, orientation and activities are designed specifically to address key national, regional and Africa-wide policy priorities.

Four distinct, but interlinking subprogrammes are in operation. These are:

- Land and Agrarian Reform, which investigates land tenure, land use, land redistribution and restitution, agricultural input and output markets, farm labour and employment, environmental and related issues
- Rural Nonfarm Development
- Regional Resource Flows
- Poverty Reduction.

7.3.6. Water Research Commission

The WRC provides leadership for research and development through the support of knowledge creating and transfer application. It engages stakeholders and partners in solving water-related problems, which are critical to South Africa's sustainable development and economic growth and is committed to promoting a better quality of life for all.

The WRC, therefore, functions as a 'hub' for water-centred knowledge. It is a networking organisation linking the nation and working through partnerships. Being an innovative organisation, it is continuously providing novel (and practical) ways of packaging and transferring knowledge into technology-based products for the water sector and the community at large, both locally and globally. The WRC will continue to play a leading role in building a sustainable water-related knowledge base in South Africa by:

- Investing in water research and development
- Building sustainable and appropriate capacity
- Developing skills for the water sector
- Being adept in informing strategic partnerships in order to achieve objectives more effectively while making optimal use of the largest global information/knowledge and other technologies available.

Two key strategic areas (KSAs) at the WRC address climate variability and climate change related projects, namely:

- Water Resources Management
- Water Utilisation in Agriculture.

The scope of the research activities under each is given in Appendix 5.

7.4 Other organisations

These include private and public companies, consultants and others such as ESKOM, Earthlife Africa, Steve Thorne cc, Peer consultants, Wiechers Environmental Consulting cc and KPMG.

Any exclusions are purely oversights and in no way intentional.

APPENDIX 1

Acronyms

CBD	Convention on Biodiversity
CDM	Clean Development Mechanisms
CSD	Commission on Sustainable Development
DEAT	Department of Environmental Affairs and Tourism
DME	Department of Minerals and Energy
DoA	Department of Agriculture
DWAF	Department of Water Affairs and Forestry
EU	European Union
EU 15	15 countries that were members of the EU before the enlargement on 1 May 2004
FAO	Food and Agriculture Organization of the United Nations
GCCC	Governmental Committee on Climate Change
IPCC	Intergovernmental Panel on Climate Change
JPOI	Johannesburg Plan of Implementation
LULUCF	Land Use, Land Use Change and Forestry
LUT	Land Use Type
NAP-CCD	National Action Programme for Combating Desertification
NEP	Net Ecosystem Productivity
NPP	Net Primary Production
SBSTA	Subsidiary Body for Scientific and Technological Advice
SIC	Soil Inorganic Carbon
SOC	Soil Organic Carbon
UNCBD	United Nations Convention on Biodiversity
UNCCD	United Nations Convention for Combating Desertification
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WAG	Washington Advisory Group
WMO	World Meteorological Organization
WRC	Water Research Commission

APPENDIX 2

Agricultural Research Council

1. BUSINESS DIVISION: LIVESTOCK

A. Onderstepoort Veterinary Institute

(i) Introduction

Climatic changes such as changes in rainfall and temperature can have a severe impact on animal health mainly as a result of the influence it has on distribution, competence and abundance of vectors and ectoparasites.

The southern African subcontinent and South Africa in particular, with its variable climate and resultant extensive range of ecological habitats, harbours an equally extensive range of external parasites of livestock. Ticks form a major parasitic component and apart from various toxicoses and direct damage caused during feeding, many species are also vectors of debilitating diseases of economic importance to the livestock sector. Major diseases transmitted to livestock and game by ticks throughout the distributional area of the relevant tick species in South Africa are corridor disease, hartwater, redwater and tick-borne gallsickness. As invertebrates, tick bioecology is extremely dependent on climate that ultimately determines their habitat and the distribution of their hosts and therefore, spatial and temporal distribution, prevalence, abundance, seasonality and resultant host infestation.

Long-term studies on the effect of climate change on vectors are basically nonexistent, climatic effect being seen only incidentally as part of protracted prevalence, incidence and seasonality studies on vectors of economic importance.

(ii) Potential influence of increased rainfall and heavy flooding

It has been shown that periods of heavy flooding lead to outbreaks of Rift Valley fever (RVf) in areas where the disease is absent in dry periods. This is the result of the spread of the mosquito vector during wet periods. Should climate change lead to increased rainfall in certain areas, the distribution of RVf may expand. Because RVf can cause acute abortions in livestock and is a zoonosis, it is of great importance to agriculture.

(iii) Potential influence of global warming

Global climate change such as the so-called greenhouse effect normally results in a mean increase in temperature above the long-term mean over an extended period of time. Research has shown that tick collections during a year characterised by a general temperature increase of 2 degrees Celsius above the 10-year average, yielded a much higher number of *Boophilus* ticks than the expected mean incidence, especially during the seasonal peak period of this species.

Global warming coupled with conditions of higher rainfall creates ideal conditions for the eventual spread of certain tick species beyond their endemic distribution into areas where transmission of disease organisms to susceptible livestock hosts could reach epidemic proportions. Climatic models such as CLIMEX® have predicted such events on a global scale for *Boophilus* ticks that transmit both redwater and gallsickness.

Climate change will not only expand the geographical distribution of known vector species, but could also increase the competence of vectors, meaning that species that were previously not indicated in transmitting disease could do so in future. For example, an outbreak of African horsesickness (AHS) occurred in Clarens, Free State, during the summer of 1996, presumably as a result of a change in weather conditions. Unpredicted outbreaks of AHS have not only occurred in the Free State, but also in the Eastern Cape and in the AHS surveillance areas (AHS free) around Stellenbosch (Western Cape).

A survey in the Stellenbosch area in 1988 indicated a very low abundance of the proven AHS vector, *Culicoides imicola*. However, recent surveys during the last two outbreaks (1999 and 2004) showed *C imicola* to be the most abundant species and abundance increased highly significantly when compared to the 1988 survey.

Furthermore, the current spread of bluetongue (bt) in Europe is presumably the result of the effect of climate change, i.e. a series of climatically-favourable years possibly allowed the vector (*Culicoides*) distribution to expand outwards into areas that were previously unfavourable for survival. A similar spread could occur in southern Africa.

Tsetse fly distribution surveys were undertaken between 1993 and 1999 in north-eastern KwaZulu-Natal. The data have been incorporated to produce a vector distribution prediction model. As the distribution of tsetse flies is mainly associated with temperature (i.e. the mean minimum of the coldest month is an indicator of tsetse presence/absence), a global (and/or regional) increase in temperature will result in an expansion of the current extent of the tsetse flies' distribution and the potential to spread Nagana. At present the southern-most limit of tsetse flies (in Africa) is more or less the Umfolozi River in north-eastern KwaZulu-Natal. The number of cattle presently at risk is about 350 000 in communal farming areas. Therefore, the southern expansion of tsetse fly distribution will result in even greater numbers of cattle being at risk of contracting the disease. This could also influence future operational control/eradication programmes and result in increased operational costs.

(iv) Potential influence of drought

Drought can have an effect on disease outbreaks, as susceptibility may increase when animals are stressed. For example, severe drought conditions in KwaZulu-Natal in 1991 resulted in an outbreak of *Trypanosomosis* (nagana) resulting in the death of 10 000 to 20 000 cattle.

Macro-climatic influences such as El Niño, typically has a cyclic influence on climate at the subcontinent level, with cycles of high rainfall followed by periods of drought. Research has shown that drought specifically has a lag effect in decimating certain tick populations, such that *Rhipicephalus appendiculatus* populations reached minimal proportions only 3 years after the 1992 drought. During periods of drought recovery, however, producers, who have relaxed tick control owing to minimal tick challenge, which, in turn, has created a susceptible livestock population, are facing a rapid tick population recovery phase with good or higher than average rainfall following such drought periods, resulting in a high tick challenge and increased disease outbreaks.

(v) Influence of micro-climatic changes

Micro-climatic changes will impact directly on tick biology, affecting, for instance, both the quality and quantity of egg hatching as well as oviposition and hatch periods owing to research-proven heavy dependence on direct temperature and humidity factors.

Similarly, manmade habitat manipulation, such as pasture burning, directly affect the micro-climate of tick habitats in an immediate increase in effective temperature which shortens eclosion periods thereby leading to short-term tick population explosions on such pastures.

(vi) Current projects addressing climate change

The ARC-OVI Entomology Division focuses on insects and mites of veterinary importance. This includes research and control of livestock pests and disease vectors, including tsetse flies (*Glossina* spp.), black-flies (*Simulium* spp.) and biting midges (*Culicoides* spp.). ARC-OVI's insect reference collections consist of several families of *Siphonaptera* (fleas), *Pthiraptera* (lice) and *Diptera* (flies). These are constantly maintained together with identification keys and databases—the latter mainly for *Culicoides* spp. Relevant projects are listed below:

- Livestock pest and disease vector biosystematics and control

- The application of newly developed technology for the sustainable control of *Glossina auteni* and *G. brevipalpis*
- Colonisation of *Glossina brevipalpis AMD G. Austeni* for tsetse fly research and development to support control of eradication actions in north-eastern KwaZulu-Natal
- Transfer of technology on sustainable tick and tick-borne disease control strategies to the livestock sector
- Transfer of technology and worm control strategies for the resource poor farming sector
- Cell-culture-derived vaccine for bovine anaplasmosis.

(vii) Possible novel projects to address climate change

The ARC-OVI is not directly involved in research relating to the influence of climate change on agriculture, however, projects on the distribution of disease-carrying vectors may indicate if these changes will have an impact on animal health. These have to be discussed with funding bodies as a matter of urgency.

At the micro-climatic level and, to some extent, at the macro-climatic level, the effect of local climatic factors on tick populations, such as high rainfall resulting in an expected higher than normal tick challenge in the following season, may be predicted and communicated through appropriate media channels to the livestock industry. However, the effect of long-term climate change on tick populations remains mainly conjecture, based on protracted studies on tick biology. In addition, baseline surveys on current tick distribution and prevalence are a prerequisite to such research as current data are at best historical, supplemented by *ad hoc* vector collections.

(viii) Projects that indirectly address disease problems that may increase with climate change

Several projects investigating improved vaccines to disease such as sub-unit vaccines to AHS, new generation vaccines to diseases such as RVf, investigating new possibilities for vaccines to heartwater and improved diagnostic methods with increased sensitivity to detect disease, could assist in ensuring that diseases could be controlled even when these have altered distribution.

B. Animal production

(i) Animal products, food security and safety

Most animal products work deals with the product (value-adding and food safety) and therefore climate change has little direct bearing. On the animal nutrition side though, the production and quality of feedstuffs is a function of climatic influences. In this regard the emphasis is on alternative feedstuffs such as low-input sources and waste materials as opposed to high-energy sources such as maize. These include more drought resistant crops such as sorghum and sunflower, the latter also in view of biofuel production. In this regard, calculations show a net reduction of CO_2 release into the atmosphere when biodiesel rather than mineral diesel is used as transport fuel. The validity of these calculations is being debated. However, at the very least, biodiesel as source of energy recylcles carbon from the atmosphere into a sustainable cycle, instead of increasing $C0_{2.}$ Biodiesel, in addition, does not release SO_2 into the atmosphere.

These arguments serve to indicate that the biodiesel initiative would contribute to the mitigation of the greenhouse effect and would contribute to the sustainability of agricultural production.

Projects that have been proposed, submitted for funding or are in various stages of implementation, are the following:

- Establishment of sustainable poultry production systems for emerging farmers
- Raw material matrix and database of southern African conventional indigenous and alternative feedstuffs

- Adaptive physiology of indigenous pigs
- Utilisation of fruit and vegetable waste as alternative feed source for livestock
- Evaluation and transfer of affordable nutritional management techniques and alternative feed resources for developing livestock farmers
- The treatment of agro-industry byproducts and their utilisation as alternative feed sources for developing livestock farmers
- Improving productivity of developing poultry and pig farmers through a feeding system combined with pasture
- Evaluation for livestock feeding of residual material after oil extraction from oilseeds
- Development of affordable, nutritious, acceptable quality value-added fresh sausages and polonies using various relevant biodiesel proteins isolate byproducts
- Healthy, nutritional products produced by use of biodiesel byproducts.

(iii) Livestock recording and improvement

The ARC-Livestock Business Development (LBD) projects relating to livestock recording and improvement relate to the recording of economically important traits, with a genetic base, in livestock. The recorded data form part of the National Database (INTERGIS) where it is transformed into information through a series of calculations and statistical procedures. These enable users, either as a primary or secondary benefit to select animals suited to specific environments (or management regimes) or to make timely management decisions to modify the production environments. Ongoing research and development related to quantitative and molecular genetics by the ARC-LBD assists in identifying suitable animals (for individual breeders or organisations) as parents for the next generation. As the traits relate to production efficiency within the environmental and production system constraints, this identification will favour the best-adapted individuals. As these traits also have a genetic base, the superiority will be transferred to the progeny. The ARC-LBD also incorporates systems of breeding goal determination and accelerated reproduction techniques to assure long-term sustainability of these programmes and to ensure maximum impact.

The effect of promoting the use of breeds adapted to the arid and subtropical environments already shows impact among livestock producers, notably at second economy level. The shift in emphasis towards economically important traits has favoured the better-adapted animals as “form follows function”.

(iv) Animal nutrition and the environment

South Africa is characterised by a largely arid interior and highly variable climate, which, because ruminant livestock production is largely natural resourced based, poses restrictions on the competitiveness of the extensive livestock sector. Furthermore, this sector is mainly relegated to agricultural areas considered marginal for cropping, characterised by inherent risk regarding sustainable production, amongst others low and erratic rainfall patterns as well as natural disasters such as droughts and floods.

Owing to the high level of climate variability and expected global warming, droughts occur regularly and under these conditions the quantity of available grazing (fodder) is a major constraint influencing animal production. The vulnerability (probability) to and preparedness for drought/climate change will determine the degree to which the drought event/climate change will result in disaster or coping therewith. Decision support systems (dss) will assist the livestock farming community to mitigate the effects and consequences of adverse weather conditions such as disastrous droughts or climate change.

The degree to which the environment is being made less resilient over time is a central theme of the White Paper on Disaster Management and therefore a first step in a dss is to map areas of risk or vulnerability. Being able to identify the areas and farming communities that are becoming more vulnerable in the face of a host of affecting factors would greatly assist policy makers to channel efforts more effectively into the areas of greatest need. The need to do so in various agro-ecological and other environments in South Africa is fundamental to sustainable development efforts.

Support and expertise that the animal nutrition and the environment team can offer in a holistic way include the following:

- Map areas of risk or vulnerability and also determine indicators of vulnerability. This would greatly assist policy makers to channel development efforts (infrastructure development, e.g. roads, fencing, stock-watering points, dipping facilities, stock handling facilities, feedlots) more effectively into those areas of greatest need.
- The development of a dss for the livestock industry, based on the agro-ecological regions (across provincial boundaries) of South Africa, should include the following components:
  - Establishing grazing capacity norms (potential) through the use of climatic/production models.
  - Monitoring of trends, both climatological and agro-ecological, that will assist decision makers, at all levels, requiring information on current yields and associated risks involved
  - Developing an early-warning system showing the extent, impact and intensity of climatic impact such as droughts and climate change.
  - Transfer of information (risk associated with production) to livestock producers and Government.
  - The development of a dss that will assist livestock producers to manage climate impact and to reduce risk both in drought conditions and post-drought recovery (e.g. with expected higher vector-borne disease incidence).
  - The “SOS” for livestock during disaster conditions constitutes Starvation, Overcrowding and Stress. To minimise the effect of disasters on animal health and possible disease outbreaks, specific veterinary information required for different localities in the country can be packaged as part of an early-warning system. Appropriate infrastructure, veterinary and paraveterinary support would be required to implement action plans.
- Maintaining a dss for crop production in association with the ARC-Grain Crops Business Division:
  - Monitoring of crop and rangeland production conditions with change in climate.
  - Establishing production risk norms for each specific season.
  - Providing climatic and agricultural outlooks and risk assessment to farmers, input providers and financial institutions.
  - Advice to farmers with regard to planting date, plant density, variety and marketing strategies.
  - Maintaining active two-way information and communication systems with clients.
- A dynamic economic (optimisation/stimulation) model to calculate the financial risk and vulnerability of livestock production systems based on climatic impact.

To develop a dynamic economic optimisation model, integrating scientific knowledge and expert opinion on climatic impact, livestock production systems and economic and financial information, as a mechanism to quantify financial risk and vulnerability for different livestock production systems and by integrating livestock production with other agricultural enterprises suited or adapted to the proposed climatic changes. Information generated with this model will be of value to, for example, livestock producers and extension officers.

C. Livestock management strategies relating to drought recovery

FODDER BANKS

Fodder banking is popularly applied in the Zimbabwean livestock business. While Zimbabwean farmers use fodder banking as part of mixed farming, specialised livestock farmers in South Africa could adopt this practice to harvest pastures during the growing season. The ARC-LBD should investigate the economics of harvesting and storing and distribution of pastures as well as methods of maintaining the nutritive value of banked fodder.

(i) Alternative feeding

Several commercial farmers are using non-traditional feedstuffs such as reeds and prickly pear for silage. Although the economics of this practice is not widely disseminated yet, there seems to be room to integrate this concept into the Land Care programme to manage invasive plants. In relation to fodder banking, the ARC-LBD should investigate the efficiency of invader plants as feeds for ruminants.

(ii) Drought feeding

Several areas in the former homelands have defunct feedlot infrastructures that were developed in response to the drought of the mid-eighties. These facilities should be reconstructed, transferred to communities and temporarily leased out to emerging feedlots with a view to use in drought feeding during drought periods.

(iii) Early Warning System

The ARC-LBD and DoA should develop a pasture surveillance programme where pasture experts will regularly survey and report on veld conditions of selected areas to advise on management decisions to be implemented.

(iv) Economics of drought management

The lack of an effective market information system often results in great losses to farmers, especially when trying to reduce herd sizes to counter drought. In relation to early-warning systems, improved access to market information such as price forecasts will enable farmers to take informed economic decisions when dealing with sales. DoA should lead a process to develop a market information module that updates farmers on demand and supply trends and the underlying associated causative variables.

2. BUSINESS DIVISION: PUBLIC SUPPORT SERVICES

A. Plant Protection Research Institute (PPRI)

(i) Introduction

Climate change will inevitably lead to the production of new crops and the emergence of new pest and disease complexes, different natural enemies will emerge in biological control programmes, natural vegetation will change as some plants are favoured by the changes while local extinctions are bound to occur.

The following broad strategies to deal with the consequences of changes rather than the changes *per se* are envisaged:

The Locust Research Unit has been remapping the outbreak area of the brown locust in the Karoo. Changing climate and the effect on rainfall patterns is believed to be responsible for the westward shift in the outbreak area over the past 30 years. What were once considered to be marginal locust areas in the Kenhardt and Carnarvon districts in the arid north-western Cape have now become high-frequency outbreak areas. Other areas in the Eastern Cape (Middelburg) have become of lesser importance as outbreak areas. The project has been mapping the new hotspot outbreak areas and has important consequences as outbreaks in the remote, uninhabited, western areas often get out of control before DoA is able to react to the situation. The project will define the new problem areas and will recommend new control strategies and the relocation of locust control insecticides and equipment.

Research has shown that alien invasive grasses will respond more favourably to an increase in carbon dioxide availability than indigenous species and out compete them, with serious consequences for the livestock industry and our biodiversity, because the invasive species are largely unpalatable. There is currently no research being conducted on the control of invasive grasses, an obvious priority for funding.

The distribution of prickly pear in the Eastern Cape illustrates the significance of climatic differences on the abundance of organisms, in this case an invasive weed. Initially, severe prickly pear infestations occurred over great areas of the eastern Karoo. These were brought under effective biological control, except in coastal areas where the higher rainfall reduces the effectiveness of the natural enemies and the plant continues to be invasive.

Depending on the extent of climate change, new crops (or varieties) will find their way into the system; the effects of introductions, irrespective of whether these are the result of climate change, are well known. New pests emerge, indigenous species adapt to the novel and often uncontested food source, etc.

The eucalyptus snout beetle is under effective biological control in the warmer parts of the country. In recent years plantations have expanded into higher, colder areas (related to climate change). The introduced natural enemy is unable to survive in the colder climate, allowing the beetle populations to reach pest proportions in these areas.

(ii) Dealing with climate change

Rather than predicting the consequences of climate change, we believe our strategy should be to assume that it will occur, albeit as a gradual process, which, in fact, has already started.

Maintaining and expanding our research capacity to deal with new and unexpected pest, disease and invasive weed problems is of the utmost importance. Dealing with "new" pests is an established concept and includes the monitoring of worldwide trends. For example:

- The need to undertake studies of the diamondback moth was identified long before local populations became measurably resistant to pesticides.
- Similarly, the South African Government is funding research on studies of so-called "emerging" weeds, which is species which currently appear innocuous, but are likely to become serious problems in the future.

Studies such as these would just not be possible without an expertise base.

International scientific contacts are equally important. When new pest situations arise— for whatever reason—access to research conducted in foreign countries is invaluable. There are countless examples of international collaborative projects, which have effectively brought potentially catastrophic pests under control.

Classical biological control cannot be implemented without international collaboration because of the search for (and exporting of) natural enemies in the countries of origin of the pests... This is becoming increasingly difficult as countries gain greater understanding of the intellectual, legal and biodiversity issues. These barriers can be overcome if our scientific credentials are impeccable and internationally accepted.

International protocols govern phytosanitory and biodiversity issues and indeed climatic issues.

(iii) Conclusion

Climate change will undoubtedly impact on the activities of ARC-PPRI. Our priorities will, however, depend largely upon changes in primary agriculture, for example, new crops will be associated with different pest and disease complexes. To deal with such new pests, our scientists will have to be alert to changes in primary production, as well as maintain the technical expertise base and their position internationally.

B. Institute for Soil, Climate and Water (ISCW)

(i) Programmes

The dynamic matrix management system of the ISCW makes provision for the allocation of projects to the most appropriate programme, including those related to climate change.

(ii) Key thrusts

- Developing and maintaining soil information systems as public assets.
- Providing a quality laboratory analytical service (soil, plant, water, ameliorant and specialised analyses).
- Maintaining remote sensing databases (NOAA, MODIS) as national assets for applications in the timely management of natural disasters (drought and migratory pests) as well as natural resource use and production.
- Maintaining an agro-meteorological network and databank as national asset for climate monitoring. This activity includes the upgrading and expansion of the climate monitoring network, as well as upgrading its data import system and quality control system.
- Core research and development on the application of the national assets in support of the sustainable use of natural resources. This activity includes evaluating and mapping anthropogenic and natural impact on natural resources and biodiversity using hyper- spectral technologies and data, development of a refined soil loss map for the RSA based on MODIS and DEM data, and the development and application of remote sensing techniques for area estimation and an agro-climatological decision support system for yield estimation.
- Contributing to sustainability of agro-ecosystems and farming systems through best practice technologies to promote rural development, food security, alleviation of poverty and human resource development.
- Developing holistic approaches to natural resource utilisation.
- Optimising water conservation technologies, such as tillage practices, mulching and water harvesting under rain-fed conditions, as well as under irrigation.
- Incorporation of databases and related information into AGIS, including the soils web, spatial data reference base, WOCAT and the Land Care information system.
- Integration of data, information and knowledge into decision support systems, such as brown locust early-warning systems and a risk management framework.
- Development of information communication technologies to facilitate access to agricultural information in rural areas.
- Evaluation of the status of soil properties as a function of anthropogenic activities.

Interventions to improve degraded land and improving soil health by enhancing soil biota activity.

Identifying and addressing the potential impacts of climate change on agriculture, through appropriate adaptation and mitigation strategies.

C. Institute for Agricultural Engineering (IAE)

The IAE's key strategic directives and objectives support cross-cutting ARC Programmes and directly or indirectly address climate change and its ramifications, with special emphasis on adaptation and the alleviation of vulnerabilities. These include risk models for irrigation scheduling; the revitalisation of irrigation schemes; agricultural water use plans for dams; biodiesel and biogas development; and agricultural product processing. These directives and objectives are to:

- Create wealth and to eliminate poverty in agriculture by increasing profits through raised production, improved product quality, value adding and reduction of input cost.
- Promote, develop and apply engineering technologies for the sustainable utilisation and development of resources used in agriculture.
- Protect, reclaim and restore deteriorated natural resources.

IAE's R&D Programmes are the following:

- Natural resource engineering, conservation and planning
- Agricultural infrastructure and animal production facilities
- Product processing engineering and renewable systems
- Mechanisation and crop production systems engineering
- Hydrology and hydraulic systems and structures
- Farm electronics and technical support.

3. BUSINESS DIVISION: HORTICULTURE

This Division, comprising the Infruitec-Nietvoorbij focusing on deciduous fruit, vines and wine; the Vegetable and Ornamental Plant Institute; and the Institute for Tropical and Subtropical Crops, conducts applied and adaptive research for the improvement of fruit and vegetable crops as well as for ornamental plants and their production systems. A most important task of the institutes, in view of climate change, is the management of genebanks of all major fruit and vegetable crops, fynbos and also the country's only wine yeast collections. Great emphasis is placed on pest and disease management.

A. Vegetable and ornamental plants

(i) Introduction

The prospect of accelerated global warming and associated regional changes in climate reinforces the need for the ARC to position itself. Declines in agricultural production associated with rising temperatures or reduced water availability, could be compensated for through the development of resistant cultivars. Breeding programmes for crops to enhance drought tolerance through conventional breeding and biotechnological techniques exist at the ARC and some seed companies.

Very few communities in rural areas of South Africa have access to adequate water for household use and even less for irrigation purposes. Securing the harvesting of a crop therefore depends largely on favourable environmental conditions as well as the selection of suitable crops. It is consequently important to focus on the development and improvement of production methods and systems to overcome adverse climatic conditions in southern Africa as well as the sustainable use of natural resources.

(ii) Current and envisaged research to address climate change

At ARC-Roodeplaat, abiotic stress research is part of our mandate. The following projects are currently running:

- The potato breeding programme has been designed to select only those breeding lines with the ability to produce high yields of good-quality potatoes under conditions of high temperature.
- Technologies to further improve the selection process are being developed. These techniques will enable researchers to evaluate a very large number of seedlings in a greenhouse. A number of potato breeding lines have been tested for both heat resistance and drought tolerance. Selected lines will be thoroughly evaluated under field conditions.
- The potato-breeding programme has already produced a number of cultivars with tolerance to drought conditions and high temperatures. One of these cultivars (Eryn) is suitable for rain-fed pro-

duction for processing while another (Mnandi) is a popular cultivar for production by small-scale farmers.

- Although potato is the most popular vegetable crop, it has a high water requirement. Approximately 74 % of area planted to potatoes is irrigated. Roodeplaat's research on irrigation scheduling contributed significantly towards improved water use efficiency for potato production.
- A drought screening and evaluation project forms part of the sweet potato breeding programme. Technologies to improve the evaluation process for enhanced drought tolerance are being developed for greenhouse and field conditions.
- Genetically modified soya-beans with a higher copy of the proline gene were thoroughly evaluated for drought tolerance in greenhouse trials over four years. These are currently in the second year of field evaluation. Results in 2004 indicated that all selected transgenic lines were more heat resistant than the conventional control cultivars. Four transgenic lines yielded higher than the parent line under water-restricted conditions. In the coming season these lines will be evaluated in different environments before entering the commercial phase.
- The effect of water stress on *Plectranthus* and wild garlic and the effect on their active ingredients are studied
- Technologies such as mutation breeding are employed to accelerate the development of indigenous vegetables tolerant to drought conditions. Amaranthus, cowpea and bambara groundnut seeds were irradiated in order to create variation to improve drought tolerance. Lines that proved to have higher drought tolerance than the non-mutated parent lines were then selected and will be evaluated in communal areas in 2005.
- The technology and infrastructure to evaluate different crops such as potato, sweet potato, soyabean, amaranthus, cowpea, and bambara groundnut in the greenhouse and in the field for drought and heat stress is available.
- Several new projects were initiated recently to optimise production methods to ensure the sustainable use of our limited and often over utilised natural resources. These include the following:
  - Production mythology to minimise crop failure under harsh climatic conditions
  - Identification of low-cost alternatives to chemicals (organic production)
  - Optimisation of cultural practices to reduce water consumption of vegetable crops.
  - Evaluation of indigenous and other vegetable crops under low-input conditions.
  - Hydroponic production systems for vegetable crops.

1. BUSINESS DIVISION: GRAINS AND INDUSTRIAL CROPS

Being proactive towards climate change, the Institute for Industrial Crops, the Grain Crops Institute and the Small Grains Institute constituting this division, develop new cultivars, manage genebanks and seed collections, manage the crops involved and research crop protection with emphasis on pest and disease management.

A. Small grains

(i) Introduction

Food security, especially in southern Africa, is directly linked to the prevailing climate. Any long or short-term changes thereof are of paramount importance in feeding our nation (providing high-quality, affordable staple foods).

Strategically, these changes are therefore instrumental to the R&D focus of the ARC, but also to the agricultural sector at large. To be proactive, access to a national, regional and, most important, an international weather climate database is imperative. The ARC, by means of various partnerships, agreements and contracts requires continuous access to a renowned, on-line and daily updated database. This should be the point of departure for all our food security R&D and should be studied frequently and the results implemented in newly developed R&D strategies.

The ARC should not study climate changes as such. but rather adapt the R&D focus accordingly to negate its effect. Furthermore the ARC should tap into international institutions with "climate change", global warming, etc., as their core business, to be continuously informed of any significant international climate phenomenon. The ARC does not have the critical mass for intellectual capital or the financial means to engage in such a long-term capital (financial/human) endeavour.

Secondly, the ARC should secure and "ring fence" adequate funding to totally fund the climate-change-related R&D projects, because local funding partners are reluctant to invest. It should be facilitated on corporate level by BDIR and not on an institute level.

Thirdly, taking cognisance of national/international climate patterns, whether these involve global warming or not, or any other significant/long-term change, these realities should be part of our decision-making process and strategic interventions when evaluating existing and new R&D projects. Indicators include minimising evaporation, cultivar choice, the incorporation of durable drought resistance into our cultivars, optimised irrigation scheduling, rotational production systems, etc. These R&D indicators should be updated and implemented rigorously during the allocation of funds.

(ii) Current projects relating to climate patterns and change

- National wheat cultivar evaluation programmes for all production areas of South Africa. In this extensive programme, among many other aspects, cultivar environment interactions and the effect on yield, growth patterns and grain quality are studied. Any shift in temperature and/or rainfall patterns will have a direct bearing on results. Drought tolerance also features.
- Long-term influence of soil cultivation methods on soils under wheat production. Zero tillage, conventional tillage, stubble burning and stubble retention and its response to long-term environmental effects are studied.
- Optimising no-till and direct seeding practices in South Africa—minimising evaporation, stubble retention, water retention.
- Winter wheat breeding programme for summer rainfall areas.
- Breeding dryland spring wheat for the winter rainfall areas.
- Breeding spring wheat cultivars for the irrigation areas. All three of these programmes have drought tolerance and heat stress as major selection criteria in developing well-adapted cultivars to our changing environment.
- Collection and maintenance of unique small grain germplasm. International germplasm is screened and evaluated for our adverse environment with special emphasis on drought tolerance. Selected germplasm is maintained in the ARC-Small Grain Institute germplasm bank and incorporated into locally bred cultivars.
- Breeding of dryland and irrigation malt barley cultivars—also for the Western Cape with its "changing" rainfall patterns.
- Monitoring of changes in soil microbial and chemical properties under conservation tillage practices.
- Investigation into precision decision making in wheat production.
- Studying the effect of extreme temperature on grain quality.

In conclusion, the institute is extremely alert to the results of any climate change and use these as R&D indicators in an effort to ensure, among many other priorities, staple food security.

APPENDIX 3

University of KwaZulu-Natal, Pietermaritzburg

School of Bioresources Engineering and Environmental Hydrology (BEEH)

POTENTIAL IMPACT OF CLIMATE CHANGE ON AGRICULTURE IN SOUTH AFRICA—AN ASSESSMENT OF THE STATE OF KNOWLEDGE AND RESEARCH REQUIREMENTS

1. The past: research completed to date

- An evaluation of potential impacts of GHG-induced climate change on agriculture in South Africa was one of several sectors on which vulnerability and adaptation (V&A) studies were performed in 1998 to 2000 through funding from the US Country Studies project on climate change.
- Output from four GCMs, downscaled by interpolative techniques to the level of Quaternary Catchments, was used in this study
- The GCMs were at the late 1990s level with spatial resolution of ~ 300 km and temporal resolution at changes in monthly means of long-term rainfall and temperature.
- The official agricultural component of the V&A study was undertaken by the ARC and only potential changes in maize production were assessed, using the CERES-maize model.
- Unofficially and using additional 1,6 x 1,6 km raster databases created when the South African Atlas of Agrohydrology and Climatology (Schulze, 1997) was researched, the School of BEEH undertook considerably more comprehensive studies on climate change impacts on agriculture through evaluations of:
  – Second-order impact (i.e. indirect consequences of basic climate change directives) such as
    * changes in heat units
    * changes in chill units
    * changes in the onset and duration of frost
  – Third-order impact (i.e. *via* changes in biological dynamics), for example
    * changes in crop yields
    * shifts in agricultural belts
    * robustness of crop optimum growing regions to climate change and
    * initial studies on changes in life cycles of selected pests.
- This information, interesting and revealing that it was, is now dated.

2. The present: current activities

Current activities on climate change impact on agriculture in South Africa are more indirect in nature, building towards possible direct impact studies in the near future, within months from the present time (i.e. November 2004).

(a) Climate database development/refinement

- Through a recently completed Water Research Commission (WRC) project, a temperature database is now available for RSA, Lesotho and Swaziland at a spatial pixel resolution of 1' x 1' latitude/longitude (i.e. ~1,6 x 1,6 km), with the facility to generate a 50-year DAILY temperature record (1951–2000) at each pixel, of which there are 428 000 in SA (Schulze and Maharaj, 2004).
- Similarly, a recently completed WRC report by Lynch (2004) currently enables quality controlled and in filled daily rainfall to be obtained from several thousand locations in South Africa.

- The South African Quaternary Catchments Database, by which South Africa is delineated into 1 947 relatively homogeneous Quaternary Catchments, is currently being populated with these new climate databases for use in a range of potential water resources (and possibly agricultural) studies.

(b) New regional climate model scenarios of climate change over South Africa

- A WRC project (2003/04–2005/03) on climate change impact on water resources in South Africa is currently being undertaken by a consortium of four universities (UKZN, UCT, UP, Wits) under leadership of BEEH.
- For this project, regional climate scenarios at spatial resolutions of 30' (~50 km) and 6' (~10 km) of a degree (vs ~300 km in the 1998-2000 study) and DAILY temporal resolutions (vs long-term monthly of the 1998-2000 study) have recently (October 2004) been developed.
- These regional scenarios, for present and 2 x CO_2 climates, are currently (November-December 2004) being configured for application with the Quaternary Catchments Database. These scenarios will be used with the ACRU agro-hydrological modelling system (Schulze, 1995) to evaluate the impact of climate change on South Africa's water resources.

(c) Climate change detection studies

- A component of the above WRC study is to assess whether, from South African climate and hydrological databases and modelling systems, any elements of climate change can already be detected.
- First results indicate, from an agricultural perspective, which over many regions of South Africa changes in frost patterns, heat units and 'temperatures over critical thresholds can already be detected (Warburton and Schulze, 2004).

(d) Assessment of agro-ecosystem sustainability over South Africa at different scales

- The above is part of a current Ph.D. study due to be completed by February 2005 (see Walker, Schulze and Kiker, 2003).
- Agro-ecosystem sustainability is being assessed at:
  - Regional scale (Highveld region)
  - Selected local scales (selected Quaternaries covering a range of climates, within the Highveld region)
  - Subsistence farmer scale (near Bergville, KZN).

The CERES-maize model, under different management treatments, is being used, *inter alia,* with plausible climate change scenarios, to evaluate the impact on grain harvest, organic matter degradation and soil nitrogen changes.

(e) Mbuluzi catchment case study

The Mjoli Dam on the Mbuluzi River in Swaziland supplies vast quantities of water for irrigating that county's sugar-cane plantations. A preliminary study has been undertaken to assess plausible climate change impact on inflows into dams, irrigation water usage and international water obligations from the Mbuluzi to downstream Mozambique. Some of the consequences of climate change, through large-scale irrigation, could be very severe.

3. The future: proposed, as yet unfunded, research activities in climate change impact on agriculture

The following proposals for climate change impact studies on the agricultural sector over the entire South Africa, or for parts of the country are unfunded yet. They do, however, build strongly on databases and detailed regional climate scenarios developed in the WRC project ended March 2005.

(a) Using the ACRU Agrohydrological Modelling System, in conjunction with the Quaternary Catchments Database for Nationwide or Provincial Scale Impact Studies

ACRU (Schulze, 1995 and updates) is a widely tested multipurpose, daily time step simulation model which, from an agricultural perspective, contains detailed routines on irrigation supply and demand, crop yields for selected crops (maize, wheat, sugar cane), primary production, sediment yield and groundwater recharge, in addition to more standard hydrological routines. It contains, for both dryland and irrigated crops, algorithms to accommodate the CO_2 feedback in crop transpiration when crop yield modules are run under conditions of enhanced atmospheric CO_2 concentrations.

- In conjunction with the new regional climate change scenarios mentioned already, simulations should be carried out for each of the 1947 Quaternary catchments on:
  - Changes in crop yields
  - Changes in irrigation water demand
  - Changes in groundwater recharge
  - Changes in the distribution and amount of runoff to fill dams
  - Changes in sediment yields under different agricultural management treatments
  - Changes in water availability for rainwater harvesting.
- Furthermore, the ACRU system should be used to undertake sensitivity studies to establish which areas in South Africa are more sensitive, or more robust, than others to the global warming directives of changes in CO_2, temperature and rainfall.
- Additionally, agricultural threshold studies should be undertaken to establish when critical production changes (e.g. 10 % yield change or 1 ton/ha change) will take place (e.g. by 2015 or 2030 or 2060) and the location where they are likely to take place first.

(b) Using new gridded temperature and rainfall databases

- The WRC is currently (2004/04–2006/03) funding a project with BEEH to revise the 1997 version of the *South African Atlas of Agrohydrology and Climatology*, using the most recent gridded databases at 1’ x 1’ (1,6 x 1,6 km) spatial resolution.
- In conjunction with plausible climate change scenarios the agricultural:
  - Second-order (frost, heat unit, chill unit) impact of climate change should be updated.
  - Third-order impact (e.g. on changes in yields, shifts in production areas of agricultural, horticultural, pasture and timber crops using more basic unidirectional models; changes in pest incidences, changes in C:N ratio which affect grazing quality).

(c) Using more complex crop growth models

More complex crop growth models such as CERES-maize could be used nationwide, or for certain regions/provinces, to assess potential:

- changes in crop production as well as
- soil organic carbon
- soil organic nitrogen and therefore the sustainability of production.

4. Conclusion

The School of BEEH is currently probably the only research group in South Africa with:

- The necessary databases
- The expertise on hand to undertake most of the tasks outlined above.

APPENDIX 4

University of Pretoria, Pretoria

Centre for Environmental Economics and Policy in Africa (CEEPA)

The CEEPA, University of Pretoria, is involved in two major projects in Africa on vulnerability, impact and adaptation of agro-ecological systems to climate change.

The first project, a study involving eleven African countries, including South Africa, is on "regional climate, water and agriculture: impact of and adaptation of agro-ecological systems in Africa". The main goal of the study was to develop multipliable analytical methods and procedures for assessing the impact of climate change on agriculture in Africa, to estimate how climate affects the current agricultural systems, and to project how climate change will affect this system in the future. The study uses four methods of analyses. Two methods are intended to generate estimates of the quantitative impact of climate change (Ricardian approach and crop response simulation modelling). In addition, hydrological modelling supplements the analysis by providing runoff and flow estimates. Further, micro-economic modelling is used to identify how African farmers already adapt to climate change. The outcome of this study is expected to be finalised by 30 June 2006. Preliminary analysis for South Africa indicates that climate change, especially increases in summer temperatures, will indeed negatively affect agricultural activities in the country with differing effects in the nine provinces. However, increased winter temperatures may be beneficial to the sector. Different segments of the agricultural sector, such as irrigated and dryland farms and small and large-scale farms may be affected differently. The inclusion of adaptation options in the analysis significantly reduces the adverse climatic effects. Specific adaptation options such as irrigation, improved farming technologies, access to labour and markets may therefore assist in reducing the expected effects of climate on the sector. These options should be the focus of policy makers in an attempt to manage the adverse effects of climate change.

The second project is being undertaken in South Africa and Ethiopia on "food and water security under global change: developing adaptive capacity with a focus on rural Africa." The goal of this study is for vulnerable rural areas in the country to be able to develop the capacity to adapt to global change with the purpose of providing policy makers and stakeholders in the country, particularly farmers and other rural stakeholders facing the largest impact from global change, with tools to better understand, analyse, and form policy decisions that will allow them to adapt to global change. The expected results of the study for South Africa are as follows:

- Characterisation of vulnerability and adaptive capacity
- Identification of determinants of adaptive capacity
- Development of integrated policy analysis tools
- Global change assessment and scenario analysis—assessment of the impact of global change on South Africa, and analysis of response options developed in South Africa based on the integrated policy analysis tool
- Development of general directions of adaptation and mitigation strategies for South Africa
- Enhancement of national and international capacity. The study is expected to be completed by January 2008.

APPENDIX 5

Water Research Commission (WRC)

1. KEY STRATEGIC AREA (KSA): WATER RESOURCES MANAGEMENT

Scope of research activity

The research focus is shifting from supporting policy making to providing guidance for policy implementation and development of policy instruments. The challenge for research in this KSA is to provide the necessary information systems, guidelines, decision-support systems, prediction tools and technologies/methodologies that support protection of water resources and equitable allocation of water to meet the needs of the environment, social and economic development. The National Water Act (NWA) places emphasis on stakeholder participation in water resource management; this requires effective participatory tools and approaches that can support multistakeholder participation in water resource management at catchments level. The potential negative impact of global climate change on water resource management is also being addressed through research within this KSA.

Completed research project

Global climate change and water resources in South Africa: potential impact of climate change and impact mitigation strategies by the University of KwaZulu-Natal; University of Cape Town; University of Pretoria; and the University of the Witwatersrand.

Abstract

Climate change, which is becoming accepted as a reality, will in all probability alter the hydrological landscape in southern Africa and impact either negatively or positively on water resources in various parts of the country. Because this will have an associated impact on society and the economy, clarification of water-resource-related impact of climate change is imperative. The five main research objectives were as follows:

- The development of plausible climate change scenarios for southern Africa
- Investigation of the potential impact of climate change on hydrological responses and associated water resources
- Investigation of possible water-related socio-economic impact of climate change in the Thukela catchments (as an example) and factors contributing to future risk
- Recommendations on some strategies to adapt to, and cope with the water-related impact of potential climate change
- Detection of effects of climate change and recommendations on appropriate monitoring systems for detection.

A range of empirical and dynamical methodologies to downscale from GCM climate-change predictions were investigated and applied. The results represent a significant advance in our understanding of the regional nature of future climate change. Methodologies have matured to the point where statements about the pattern of climate change at a regional scale can be made with some confidence. However, confidence is still weaker for statements regarding the magnitude of change associated with this pattern. Nevertheless, the advances made are a solid foundation for future development and reveal priorities for future work.

In order to simulate hydrological change, the ACRU model, supported by a quaternary catchments database, was run for the entire South Africa extending into southern Africa, using one of the several investigated downscaling approaches (specifically, C-CAM modelling, yielding daily climate time series relating to the present and a future climate scenario at appropriate grid points) to provide the necessary input information. Results indicate some hydrological change "hotspots", which may need to be acted upon by water resource managers. The present winter rainfall region in the Western Cape is one such hotspot of major concern. The credibility of the outcome of this study depends to a large extent on how the downscaled output of daily climate values from C-CAM agree with corresponding outputs from other downscaling approaches. Agreement was generally good for the Western Cape (hotter, with drier winters) and for the eastern escarpment and eastward (warmer, moister), but less consistent for transitional areas elsewhere in the country.

From climate records of the past 50 years, elements of climate change can already be clearly detected in certain regions within southern Africa, be it for derivatives of rainfall, temperature or for hydrological responses. Not all areas display equal change and in some areas no change can be detected yet.

Vulnerable communities in southern Africa already have to cope with multiple stresses, of which climate variability is only one. Climate change will add an additional layer of stress, to which adaptive strategies and adaptation policies will have to be directed.

In identifying adaptation strategies for the region's water-related sector (including both small and large-scale agriculture and the environment), emphasis will have to be on the "uniquely South African" situation, with its juxtaposition of the developed *vs* the underdeveloped sectors of the population and economy. Strategies will have to take cognisance of specific *local* situational contexts, on the one hand, and *national* level policy and institutional issues, on the other. Successful adaptation strategies will generally be closely aligned with effective integrated water resources management (IWRM).

Ongoing research project

The secondary effects on water resources owing to primary changes in precipitation and temperature associated with climate change. Contractor: University of Cape Town; Term: 01/04/2005/–31/03/2008.

Summary

The WRC is currently funding a project to investigate the potential impact of global and regional changes in climate and climate variability on water resources, however, this focuses only on hydrology at present. There are likely to be secondary effects on water resources arising from changes in flow regimes and ambient temperature—these include changes in nutrient cycling, changes in processes affecting sequestration of toxic substances such as metals, changes in chemical and biochemical oxidation and reduction processes and changes in background concentrations of dissolved salts. The complex changes in water quality, water quantity and temperature as a result of climate change will, in turn, have effects on aquatic ecosystem structure and function, with further implications for the quantify, quality, reliability and availability of water resources. This project will build on recent and current research within the WRC and other organisations, to generate potential scenarios for the secondary and tertiary impact of climate change on water resources, with the aim of supporting the development of policy responses and coping mechanisms.

2. KEY STRATEGIC AREA (KSA): WATER UTILISATION IN AGRICULTURE

Scope of research activity

Utilisation and development of water resources in agriculture must be analysed in relation to the needs and requirements of people. People using water in agriculture comprise a diverse group of subsistence, emerging and commercial farmers within the following interrelated sub-sectors of agriculture namely:

- Irrigated agriculture
- Dryland agriculture
- Woodlands and forestry

- Grasslands and livestock watering
- Aquaculture

Water users in all the abovementioned sub sectors, as well as organisations such as Water User Associations (WUAs), cooperatives, agribusinesses and government departments serving water users, are the clients or target groups of the research output. The point of departure of applied research is therefore the real-life problems experienced by primarily water users and related organisations, for irrigated and rain-fed crop production, fuel wood and timber production as well as livestock and fish production.

Research as a problem-solving process must provide information and technologies and models, which can be applied by present and future generations of water users. The overall objectives are to utilise scarce water resources efficiently, beneficially and sustainably to increase household food security and farming profitability and thereby improve economic and social welfare. In all instances the priorities involve enhancement of management abilities in order to improve the efficiency of water utilisation for agricultural and food production.

New research project for 2006/07

Applications of rainfall forecasts for agriculture-related decision making in selected catchments.
Contractor: University of KwaZulu-Natal; Term: 01/04/06–31/03/11.

Summary

The South African climate is highly variable over short and longer periods. These inter and intra-seasonal variability is likely to be amplified by the global change in climate. Agricultural production is intrinsically linked to climate variability. Many agricultural decisions are made, based on climate (short, medium and longer-term) information and assumptions. Farmers need information to help them plan for planting, irrigation and harvesting of their crops.

Weather forecasting can aid users to make better-informed decisions and assist in planning activities. They have the potential to reduce risk in the long term and improve water-use efficiency. Forecasting involves computer models, observation and knowledge of trends and patterns. Using such tools, meteorologists can reasonably forecast weather conditions up to five days in advance. Longer lead-time forecasts (weeks, months) are referred to as climate forecasts. Such forecasts, usually made in terms of categories (above, near and below normal) and probabilities, are becoming more skilful as research progresses. However, gaps exist between the weather and climate forecasts and linking them to agro-hydrology and applications in agricultural decision making. The project aims to develop techniques and models for translating forecasts of up to one year in advance into applications for decision support.

The 2001 Strategic Plan for South African Agriculture states that one “component of the comprehensive risk management strategy is an early-warning system that includes adequate access to and utilisation of timely, accurate, relevant, and free information about the weather”. Since the end of 2002, the national Department of Agriculture has been advising farmers on climate conditions and practices to follow, based on a long-term climate outlook. It is envisaged that this project will develop an early-warning system with different lead-times that could reduce farmers’ susceptibility to adverse weather conditions. Although the project will focus on two or three critical catchments, the findings of this study will be extrapolated to other catchments.

3. GENERAL

The Water Research Commission has funded several projects over almost two decades on research on climate variability with a focus on forecasting, modelling and database development. These include *inter alia*:

- Development of a raster database of annual, monthly and daily rainfall for southern Africa (WRC Report No. 1156/1/04);

- A flood now casting system for the eThekwini metro: Volume 1 and 2 (WRC Report No. 1217/1/04 and 1217/2/04);
- Spatial interpolation and mapping of rainfall (Simar): Volume 1 – 3 (WRC Report No. 1151/1/04; 1152/1/04 and 1153/1/04);
- Regional model development for simulating atmospheric behaviour and rainfall over southern Africa (WRC Report No. 1261/1/05);
- Dynamical modelling of the present and future climate system (WRC Report No. 1154/1/04).

These and other projects have resulted in more comprehensive datasets and a better understanding of weather and climate variability and refined forecasting tools. It is therefore in the interest of the WRC to see this research utilised.

4. WATER RESEARCH COMMISSION REPORTS RELATING TO CLIMATE CHANGE

806/1/01: Dynamical modelling to investigate the regional climate response to global change forcing

904/1/03: Seasonal climate predictions with a coupled atmosphere/ocean GCM: A contribution to water resource management over southern Africa

1154/1/04: The dynamical modelling of present and future climate system variability at inter-annual and inter-decadal time scales

1261/1/05: Regional model development for simulating atmospheric behaviour and rainfall over southern Africa

1430/1/05: Climate change and water resources in southern Africa

1500/1/06: Climate variability, climate change and water resources strategies for small municipalities. RB/EDT/12/05/2006