

SOUTH AFRICAN RISK AND VULNERABILITY

Atlas



science
& technology

Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

Mapping the way to a resilient future

“The Atlas will play a crucial role in enhancing global change science and technology, improving predictions, informing decision-making and putting in place strengthened networks to monitor global change.”

- Imraan Patel, Chief Director - Science and Technology for Economic Impact, DST



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The rate of human-induced change is unprecedented. There is now unequivocal evidence that human activities are affecting the Earth's system at the global scale. Increasingly strong evidence suggests that the functioning of this system is changing in response.

Global change is more than climate change. Global change refers to any changes in the Earth system. The Earth system encompasses the atmosphere, biosphere, water, ice, and land. It also involves different processes and their interactions with social and economic systems. Many changes in Earth system functioning directly involve changes in climate. The Earth system includes, however other components and

processes, bio-physical and human, which are important for its functioning.

Some Earth system changes, natural or human-driven, can have significant consequences without involving any changes in climate. Global change does not operate in isolation but rather interacts with an array of natural processes and human-driven effects in complex and multidimensional ways; at local, regional and global scales.

Climate change is “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods”

(United Nations Framework Convention on Climate Change).

Global warming refers only to the overall warming of the planet, based on average increases in temperature over the entire land and ocean surface. It is important to note that climate change is more than simply an increase in global temperatures; it encompasses changes in regional climate characteristics, including temperature, humidity, rainfall, wind, and severe weather events, which have biophysical, economic and social dimensions.

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“Observational evidence clearly shows that many natural systems are being affected by increases in air and ocean temperatures as well as fluctuations in the amount and timing of rainfall events. This is likely to have significant implications for human well-being.”

Dr Bob Scholes, CSIR systems ecologist and principal investigator in the Southern African Millennium Assessment

As global change research is revealing rising evidence of climatic and associated changes, it is becoming increasingly clear that Southern Africa is likely to be severely affected by future global change.

The region is considered to be a priority area for creating an enabling environment for adaptation as these changes may impact many sectors of Southern African society. It has become essential for critical sectors in South Africa to understand global change and its possible impacts on society to enable them to formulate and improve strategic adaptation responses.

South African scientists have gained international recognition for their significant contribution to international global change research. The next vital step for them is to translate global change science into concrete strategies and policies for the country as a whole.

Decision-makers in critical sectors need information associated with the impact and risk of global environmental change. This implies that risk and vulnerability need to be defined and examined in the context of global change. Raw global change data need to be analysed and reworked into practical information sets to assist policy-making in South Africa.

INTRODUCTION

Why a Risk and Vulnerability Atlas?

South Africa's Department of Science and Technology (DST) identified a Risk and Vulnerability Atlas as one of the best and most practical ways to bridge the divide between scientists and policy/decision-makers.

The South African Risk and Vulnerability Atlas project was designed to provide global change sensitivity and vulnerability information at regional, national, provincial and municipal levels. The Atlas assesses and channels easily understood and relevant information on the impact and risk associated with global change in the region to

stakeholders. The information assists in decision-making on how to adapt and respond to environmental pressures, including the impact of climate change.

One of the major benefits of the Atlas is that it consolidates the latest findings on global change impacts on key sectors in South Africa (such as biodiversity, water and agriculture). Such information, made available through the Atlas in spatial and non-spatial format, has begun to serve the increasing requests by stakeholders in Southern Africa for information about global change impacts on key sectors in the area.

Do stakeholders participate in the process?

Interaction with Atlas stakeholders has proved vital in assessing the nature of information that should reside in the Atlas. It has also served to convince stakeholders to become active members of the Atlas user community — by accessing and using generic information provided through the Atlas portal, 'translating' and interpreting such information for their unique contexts and sectors, and sharing their own value-added spatial and non-spatial information with the Atlas community.

To facilitate ongoing stakeholder involvement, the project has a dedicated stakeholder outreach component. Risk and Vulnerability Assessment Centres will also be established at rural universities in the near future.



The question has shifted from ‘Will we have to deal with the consequences of global change’ to ‘How should we adapt to the changes which are most likely to occur’.

How can the information in the Atlas be used in decision making?

The human capital development component of the Atlas focuses on training current and potential users in the supporting technology and application of this technology. To facilitate training, the technical data in the Atlas is supported by narratives, which include case studies in which the global change scientists involved in the project demonstrate, in a practical way, how the information can be used in decision making and policy formulation.

The case studies facilitate a virtual exploration of global change impacts, risk and vulnerability, as well as adaptation and mitigation strategies. The case studies enable Atlas stakeholders to explore synergies and apply relevant scientific principles underpinning the case studies to their own local adaptation strategies and implementation plans.

In turn, users are encouraged to feed the results of their projects into the Atlas data repository, which does not only cut down on duplication and drive down costs, but ensures that best practices are shared.

What is the difference between the hardcopy Atlas and Atlas electronic spatial database?

The South African Risk and Vulnerability Atlas consists of two formats — a hardcopy prototype of the Atlas which was launched in 2010, and the Atlas electronic spatial database — an electronic data repository on global change in South Africa which is continuously updated with new research by national and international global change researchers from various disciplines. The electronic spatial database captures data related to aspects such as groundwater, surface water, forests, biodiversity, human health, crops, demographics, economics and social dimensions.



CASE STUDIES

Both the hardcopy and electronic versions of the *South African Risk and Vulnerability Atlas* include case studies in which scientists demonstrate, in a practical way, how typical research findings accessible in the Atlas can be used in decision making and policy formulation.

Current case studies contained in the Atlas deal with the following crucial issues:

- environmental health
- potential impacts of climate change on South Africa's coastal zone
- adapting to climate change in a diverse landscape
- building resilience to climate variability and change in the City of Johannesburg
- climate change and water resources
- climate change implications for water and land use within the agricultural sector



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Imraan Patel, Chief Director - Science and Technology for Economic Impact, DST

The primary agricultural sector fulfils a prominent role in South Africa's economy and is vital to the development and stability of the southern African region.

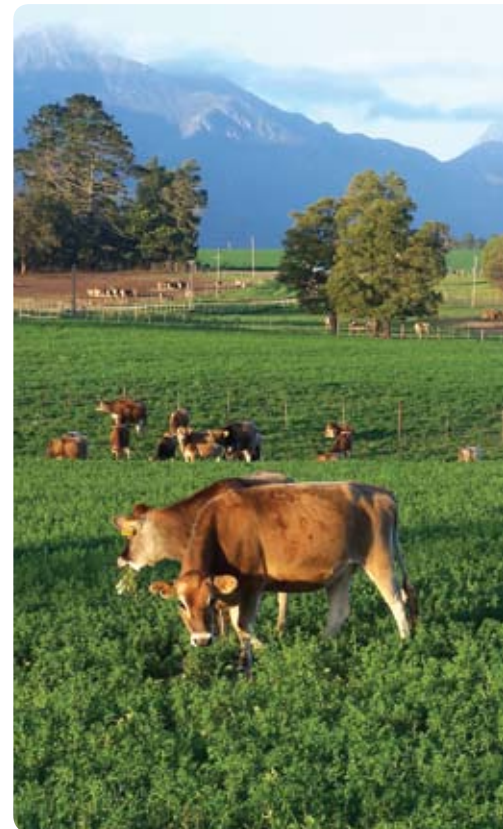
CLIMATE CHANGE IMPACTS ON AGRICULTURE AND WATER: SOUTH AFRICA'S GARDEN ROUTE

Frequent severe water shortages, land degradation and loss of biodiversity are putting South Africa's Garden Route under strain. Climate change scenarios predict a warmer climate and more irregular and intense rainfall events for the area.

Climate change is already posing a major threat to agricultural industries in the region, which in turn puts pressure on water and land resources. Increasing the risk are, in certain cases, poor land and water management practices coupled with climate change. It has become vital for researchers to investigate the impact of climate change on agriculture in the area to identify vulnerable areas and avoid further risk.

Specific risks associated with climate change in the region water availability and demand. According to the Department of Water Affairs, the irrigation sector (mostly pastures and vegetables), requires nearly half of the water available for the area. The area is already experiencing a shortfall in water supply, to which the dairy industry in particular is vulnerable as water availability affects grazing security and the condition of livestock.

The Wildlife and Environment Society of South Africa (WESSA) initiated a research project to determine the implications of global change for land and water use within the agricultural sector of the Garden Route. The project is partly funded by the Eden District Municipality.



AGRICULTURE

Economic benefits of agriculture versus land and water conservation

Research is driven by concerns that, confronted by global change, farmers and municipalities will tap more water resources and develop more land currently occupied by indigenous vegetation worthy of conservation. Farmers' perceptions of climate variability and change strongly influence their reaction to climate change. Their adaptation decisions are largely dictated by the economic benefits associated with improved land and water conservation practices.

This case study aims to make key global change science and impact information available to stakeholders such as government departments, municipalities and civil

society. The findings of the study will assist stakeholders in their assessment of future pressure on water and land resources under changing climatic conditions, and will hopefully encourage significant reduction of water abstraction and pollution by the agricultural sector.

The case study also serves as an example of how decision-makers can apply existing climate risk and vulnerability information to the agricultural sector.

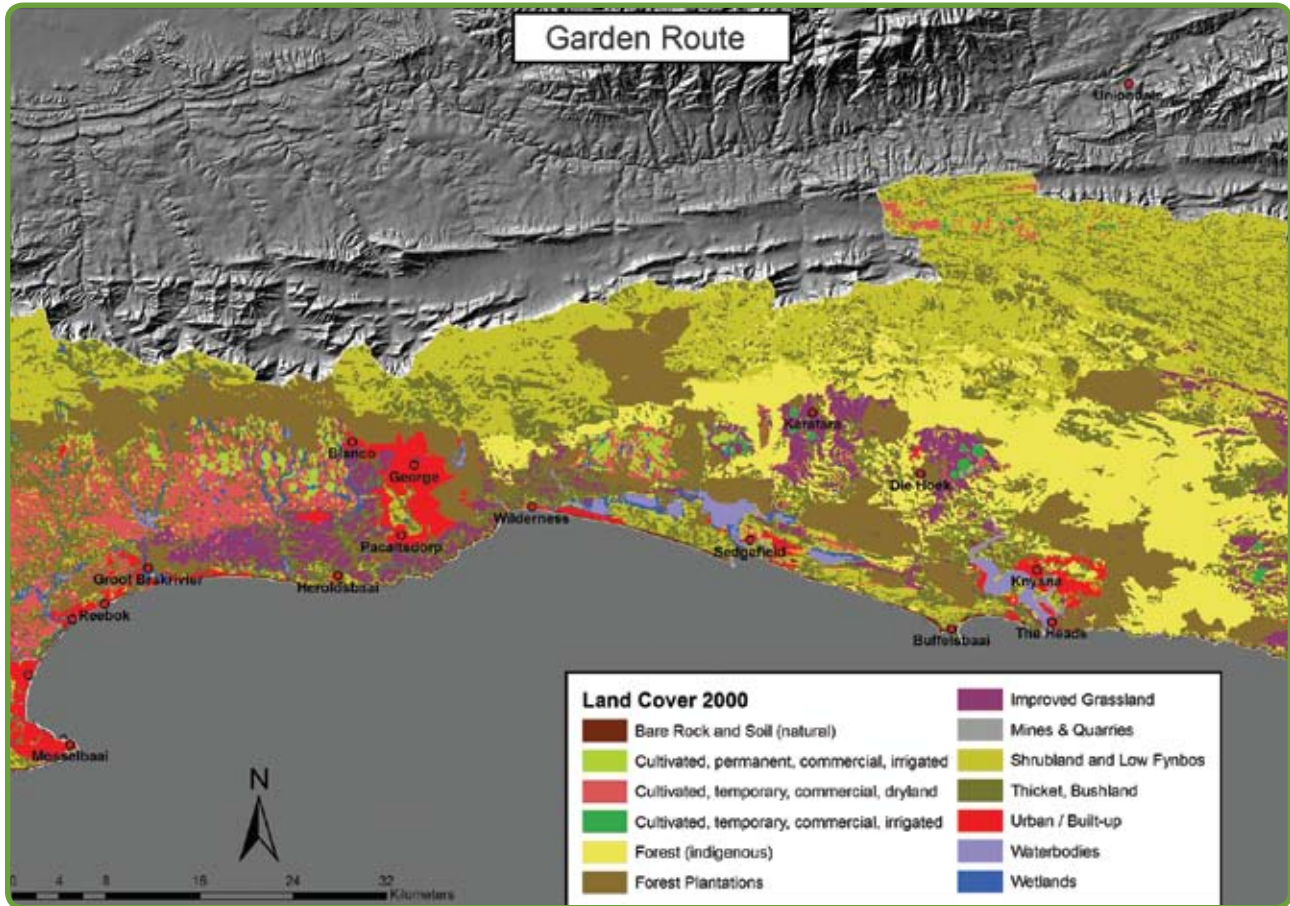
Collaboration between the Western Cape Department of Agriculture, Eden District Municipality, WESSA and the Nelson Mandela Metropolitan University on the case study has resulted in multi-institutional data sharing – for the benefit of agriculture and food production in the region.

For more information, contact Daleen Lötter on dlotter@csir.co.za or go to www.rvatlas.org/casestudies/study06.php.

The Cape Garden Route comprises a range of biologically diverse terrestrial and aquatic ecosystems, mountain ranges, indigenous forests and estuaries.



AGRICULTURE



CLIMATE VARIABILITY AND CHANGE: CITY OF JOHANNESBURG

Global change - including climate change and climate variability - are all key issues potentially determining the progress of development in Southern Africa. Attaining a better understanding of the relationship between climate variability and climate change remains a key challenge.

The City of Johannesburg, for example, usually experiences a number of thunderstorms in the summer season. These storms can either be a challenge (infrastructure damage) or an opportunity (potential source of water if effectively captured). The issue now arising in view of change is whether these storms are changing in type, in number and in the amount of rainfall they bring.

According to available research, extreme rainfall events such as thunderstorms may increase in frequency and intensity given global change. Much more investigation is needed to confirm such outlooks. As this case study attempts to show, the uncertainty around storm frequency, occurrence and magnitude may compound urban environmental issues, including placing additional stresses onto the system.

Severe storm events

The City of Johannesburg, one of the largest urban conglomerations in Africa, has recently struggled with severe storm events that resulted in the loss of life. The City has seen remarkable growth over recent years. People flock to the City for employment and often find accommodation in informal dwellings located close to water streams and rivers that are vulnerable to a range of stressors including storm events.

Poorly constructed dwellings and poor communities living close to water courses may be at risk.



CITY OF JOHANNESBURG

The aim of this study was to examine the nature of severe storm occurrence in Johannesburg. Actual rainfall data from 1960 to 2008 were used and changes in storm frequency, magnitude and amount of rainfall per storm were tracked. The results were then compared with the recent work completed for the City of Johannesburg's Adaptation Plan (Johannesburg Draft Adaptation Plan, 2009). The City was informed of the study and several meetings were held with Metro representatives.

Initial findings support suggestions from climate models that while rainfall totals may decrease over time, the amounts per event may increase, possibly putting additional pressure on blocked drains, poorly drained areas and poorly maintained urban areas.

In an attempt to improve this knowledge, the first part of the study aimed and will continue to descriptively analyse thunderstorms in Johannesburg. The criteria used to identify a thunderstorm were the occurrence of rainfall, cumulonimbus cloud as well as the actual observation of a thunderstorm. Once the occurrence of the storms had been determined, the frequency of storms as well as the associated rainfall was tracked.

The key emerging finding is that even though there has been a decrease in total rainfall, the data indicate that rainfall per event has increased. More detailed investigations are now underway.

These initial findings support suggestions from climate models that while rainfall

totals may decrease over time, the amounts per event may increase, possibly putting additional pressure on blocked drains, poorly drained areas and poorly maintained urban areas. Poorly constructed dwellings and poor communities living close to water courses may be at risk.

There are several lessons that can be drawn from this initial study, one of the most important being that decision-makers are faced with various planning decisions about managing urban spaces given scientific uncertainty of the climate system.

For more information, contact Prof Coleen Vogel on Coleen.Vogel@wits.ac.za or go to <http://www.rvatlas.org/casestudies/study04.php>.



ENVIRONMENTAL HEALTH: BRIDGING THE GAP BETWEEN TRADITIONAL HEALTH CONCERNS AND A CHANGING CLIMATE

It has become vital to know more about human behaviour, new technologies, indigenous knowledge and social livelihoods to be able to put effective adaptation and mitigation strategies in place to protect human health.

It is likely that some of the most devastating effects of global environmental change will be on human health. It has become vital to know more about human behaviour, new technologies, indigenous knowledge and social livelihoods to be able to put effective adaptation and mitigation strategies in place to protect human health.

Health risks from global change include those resulting directly from increases in extreme disaster weather events such as floods, and from higher levels of air pollutants, pollens, spores and moulds. Other risks are indirect, such as an increase and shift in vector-borne, water-borne and food-borne diseases and infections, and malnutrition caused by a decrease in food production.

Global change impacts will not be experienced proportionately around the world — vulnerable populations will be most at risk. Rural communities in South Africa's Limpopo Province, for example, are vulnerable to health risks from global change mainly because they do not have access to adequate health information and services. For many years, these communities have been at risk of malaria. Subtle changes in climate, particularly warmer temperatures, may worsen this risk.

This University of Pretoria case study is investigating changes in climate and malaria incidences in Limpopo Province. Researchers have already found a correlation between certain climatic factors and malaria cases.

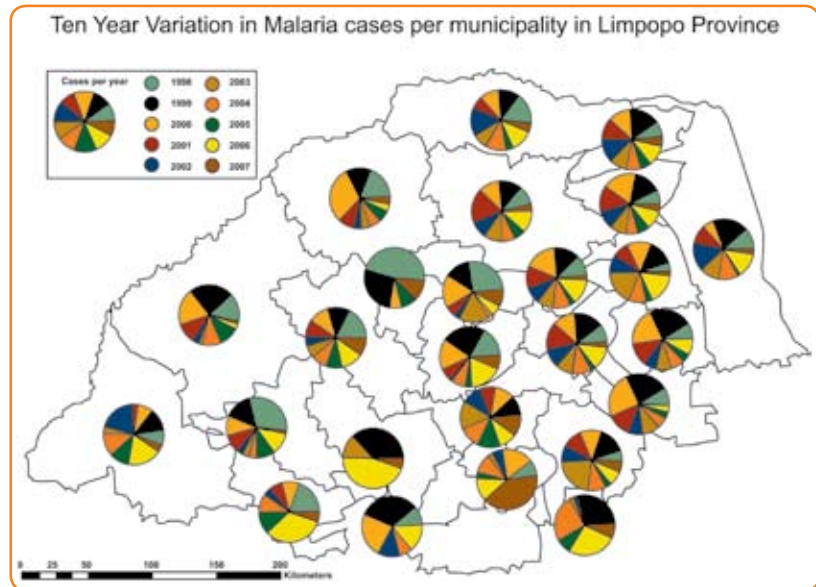


They have also highlighted areas where people were most prone to contracting malaria.

Adaptation and mitigation strategies are necessary to increase the preparedness and resilience of communities. Strategies include sustained public health surveillance, disease prevention, dissemination of information aimed at adaptation and mitigation, and improving early-warning systems.

The findings of the case study are important for public health services and research into health issues. The South African Risk and Vulnerability Atlas aims to assist researchers and health workers in identifying and understanding malaria as well as other current and future health problems.

For more information, contact Dr Caradee Wright on cwright@csir.co.za, Dr Jane Olwoch on jane.olwoch@up.ac.za, or go to www.rvatlas.org/casestudies/study01.php.



Malaria kills more than
3 000 children per day in
sub-Saharan Africa.

ADAPTING TO GLOBAL CHANGE IN A DIVERSE LANDSCAPE: THE KRUGER TO CANYONS BIOSPHERE RESERVE

The Kruger to Canyons study area (K2C), located in the north-east of South Africa, was designated as a Biosphere Region in 2001 under UNESCO's Man and Biosphere Programme to preserve the integrity of the conservation areas while improving the livelihoods of the people who live within its borders. One of the consequences of conservation initiatives in the past has been the economic underdevelopment of rural areas adjacent to conservation areas.

Being home to just over half of the bird and mammal species in South Africa, K2C displays a substantive topographic and climatic diversity, and is the site of multiple stressors. This makes it an excellent subject for considering how global change impacts might be successfully managed in a diverse landscape. Given the general consensus in the scientific community on the existence of climate change, the question has shifted from: 'Will we have to deal with the consequences of climate change' to 'How should we adapt to the changes which are most likely to occur'. This has led the scientific community to engage in research which allows governments and other

stakeholders to create pro-active responses to the expected climatic changes rather than a reactive response when the consequences forecasted actually occur.

The case study is focused on the highly diverse land use area of K2C where a range of stakeholders are active, including Bushbuckridge Municipality, South African National Parks, Mpumalanga Parks Board, the Department of Water Affairs, the Department of Agriculture, Forestry and Fisheries and a range of civil society initiatives.

By incorporating state conserved land, communally managed nature reserves, communally grazed areas, former homeland type dense settlement areas, commercial agriculture, private conserved areas, commercial forestry and provincial conservation, the area is highly appropriate to demonstrate the potential benefits of more accessible information on global change projections, as well as risk and vulnerability planning around potential impacts for the area.



Global changes may already be occurring

Previous studies indicate that global changes in the area may already be occurring. Key areas of critical impact include water supply and quality; commercial agriculture; forestry (including the reversion of commercial forestry in certain areas); health; commercial rangeland management; communal agriculture and livestock; and conservation management at the landscape scale (Kruger National Park).

Part of the K2C area comprises former homeland areas, with an attendant backlog of service delivery and infrastructure as well as a considerable health burden (60% HIV infection rate and chronic lifestyle diseases such as strokes, diabetes and heart attacks). These communities have a high dependence on natural resources that provide a free or cheap alternative to other commercial commodities. Natural resources are already under increasing pressure from changing environmental conditions, which could increase the vulnerability of these rural communities to future global change.

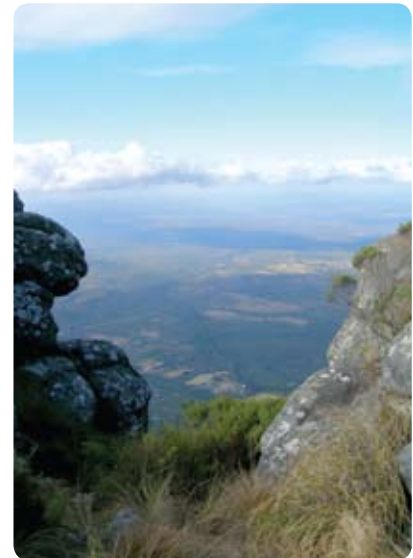
The aims of the case study are three-fold:

- to determine the changes in climate for the region and the resulted impacts on key sectors - agriculture, conservation, water and rural and urban planning;
- to determine how this information can be used by the diverse stakeholders in the area; and
- to determine the potential for developing systematic methods for risk-based planning and decision-making at the landscape scale.

The outputs of this project include diverse stakeholder planning and decision-making for the area, which is more directly informed by global change predictions, and improved resilience of such sectors under global change.

For more information, contact Nikki Stevens on nstevens@csir.co.za or go to <http://www.rvatlas.org/casestudies/study03.php>

Reference: Davis C.L, 2010: A Climate Change Handbook for the North-Eastern Region of South Africa, CSIR, Pretoria.



COASTAL AREAS

POTENTIAL IMPACTS OF CLIMATE CHANGE ON THE COASTAL ZONE: HOW FAR FROM THE SEA SHOULD WE BE?

Rising concentrations of greenhouse gases in the atmosphere result in an increase in surface temperatures, which in turn leads to an increase in sea levels through the interaction of various processes such as thermal expansion of the oceans and melting of glaciers. It is predicted that climate change may also bring greater storm intensities. This makes coastal settlements vulnerable, especially as coastal zones are densely populated and growing rapidly.

Studying climate change risks in coastal areas aids design and safe location of new developments and infrastructure, and assists in identifying adaptation options for existing developments that are at risk.

Since 2005, South Africa's KwaZulu-Natal coastline has been experiencing a particularly high number of extreme storm events. Although the storms caused coastal erosion and flooding along the coast, some parts of the coast eroded more than others. It is important to determine which parts of the coast are more vulnerable than others under current conditions.

Determining safe areas along the coast

Another important issue to predict is how areas already vulnerable to erosion may become more prone to damage in the future due to the effects of climate change. The prime factor leading to damages in the past and increased risk in the future is developments located too close to the sea. There is a need to determine safe areas along the coast, which requires prediction of future shoreline locations.

One of the impacts of sea level rise is that waves will reach further inland than at present, which implies that present coastal development setback lines (of which few exist) have to be adapted. A coastal development setback line is a line landward of which fixed structures (such as houses and roads) may be built with reasonable safety against the physical impacts of the coastal processes such as sea storms, wave erosion and runup. Additional factors which determine the location of setback lines are storm wave runup elevations and how far the shoreline will retreat due to erosion, which, in turn, are affected by the amount of sea-level rise that is expected and the predicted increase in storminess.



Coastal resources are expected to be affected by a number of consequences of climate change — higher sea levels, higher sea temperatures, changes in precipitation patterns and sediment fluxes from rivers, altered oceanic conditions as well as changes in storm tracks, frequencies and intensities.

As part of current research, realistic scenarios of sea-level rise and potential increases in wave heights were determined,

as well as preliminary calculations of the resulting effects on erosion and runup. Another factor that needs to be considered is the amount of erosion that can occur during a storm. The output of this study is predicted runup lines including the effects of long-term erosion caused by sea-level rise.

Shoreline erosion depends on a number of factors, some operate on a large scale and others are of a local nature. In this study

it was highlighted that the local effects are very important. Simply choosing a presently higher contour line to represent a future shoreline is insufficient. More realistic wave runup and erosion prediction techniques are required.

For more information, contact André Theron on atheron@csir.co.za, Hardus Diedericks on gdiedericks@csir.co.za, or go to <http://www.rvatlas.org/casestudies/study02.php>

The predicted setback lines are useful for decision-makers in coastal zone management and municipalities, city planners, developers and home owners. Decision-makers can use the information to better plan future developments and develop the coast according to natural cycles.

COASTAL AREAS



Coastal areas within Table Bay near Cape Town were selected to illustrate how runup calculations can be used to highlight present and future vulnerable areas. Runup data were collected following the 2008 storm and some of these runup lines are presented in Figure 1. Figure 2 illustrates what the combined impacts of shoreline erosion and a higher wave runup could mean for a 0.5 m rise in sea level and a 1-in-20-year sea storm.

GLOBAL CHANGE AND WATER RESOURCES: ALTERED WATER AVAILABILITY AND INCREASED SOCIETAL RISKS

The effects of climate change on South Africa are expected to include a change in the amount and variability of rainfall. Air temperatures are likely to increase, which will increase evaporation. The net effect will be a decrease in the amount of water in our rivers and water stored in the ground. These changes are critical as South Africa is already using almost all of its available water.

Climate change poses three major risks to our nation's water resources:

- increased incidence of drought as rainfall decreases in many areas
- increased incidence of floods as the incidence of very heavy downpours increases
- increased risk of water pollution linked to erosion, higher temperatures and algal blooms

Reducing water available for irrigation during droughts could reduce food production and result in food shortages. The most vulnerable areas are those where people depend on a single, limited resource such as a small dam or low-yielding borehole and have little water storage capacity to meet their needs during the dry season or droughts. The most vulnerable groups are poor communities who lack the money, necessary skills, trained people and technologies to solve water problems, especially purifying and storing water.

Although South Africa may be able to engineer expensive solutions to solve its water problems, the first and most important measure is to become aware of the risks, and to conserve water.

Pinpointing high-risk areas

This case study attempted to determine how much water is available in different parts of the country, and how this could change in the future. The researchers located information that can be used to assess how vulnerable people are (communities, towns, cities) to changes in their water supplies. The information was then used to prepare maps to show the areas where the risks are likely to be greatest.

The study showed that the risks are widespread, but particularly high in the drier parts of the country. It also highlighted areas where there are dense settlements of poor people with limited adaptive capacity. Research indicated that groundwater storage will become more important in an increasingly uncertain future.



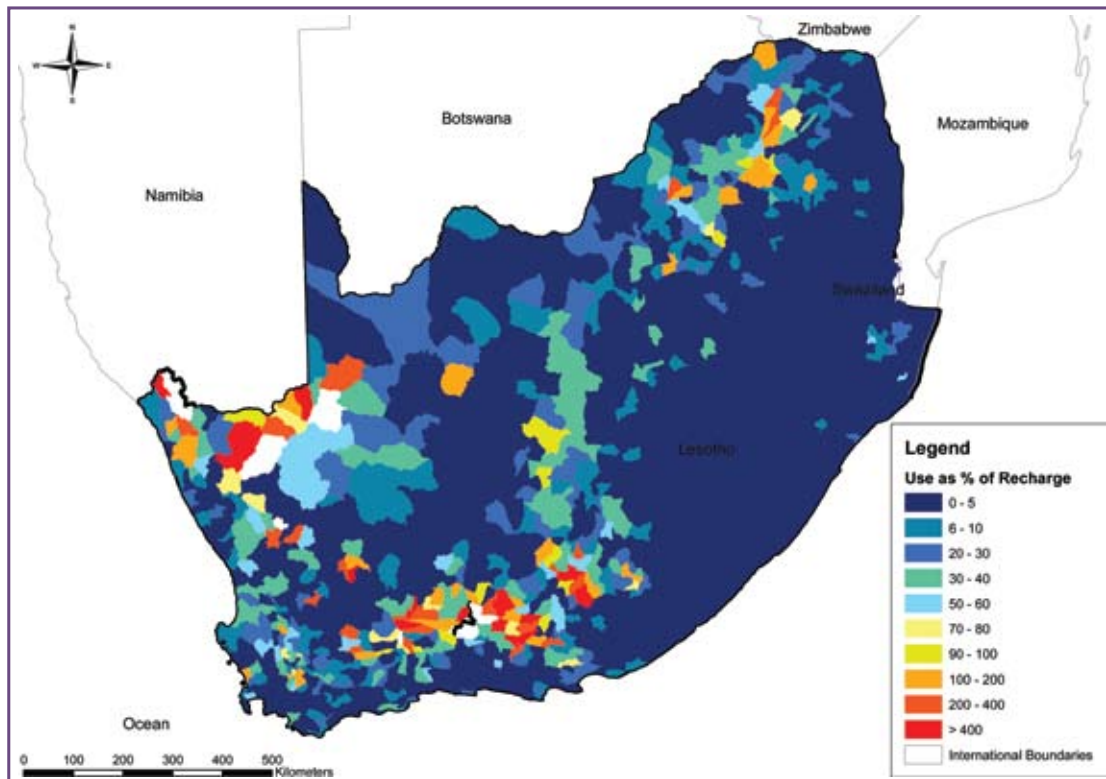
WATER

The information derived from the study is useful for the South African Risk and Vulnerability Atlas particularly because water is a critical resource threatened by several factors, including climate change. The Atlas will help people identify what risks they face and where these risks may combine to increase their vulnerability.

A wide range of institutions and people can potentially benefit from these assessments, ranging from national government to individuals. Planning decisions, such as those about whether or not to allow new residential or industrial developments, should take account of the fact that there will be less water available in the future and

that it may need new treatment technologies to make it drinkable.

For more information, contact Dr Christine Colvin on ccolvin@csir.co.za, Dr David Le Maitre on dlmaitre@csir.co.za, or go to <http://www.rvatlas.org/casestudies/study05.php>







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