# Long Term Adaptation Scenarios

# Research Flagship Programme (LTAS)

# Summary for Policy-Makers

High-level/key messages emerging from LTAS Phase 1 (completed in June 2013)



## Introduction

The Long Term Adaptation Scenario Research Flagship Programme (LTAS) aims to respond to the South African National Climate Change Response White Paper (NCCRP, para 8.8) by developing national and sub-national adaptation scenarios for South Africa under plausible future climate conditions and development pathways (see Figure 1). This is a complex task which requires the projection of climate change impacts for key sectors and an evaluation of their socio-economic implications, in the context of development needs and aspirations of these sectors. This process is being followed in two major phases to build a sub-national and national 'scenarioscape' within which adaptation to climate change will occur. In addition, there is a need to assess the extent to which the regional and international context might influence the national adaptation response.

During its first phase summarized here, the LTAS process developed a consensus view of climate change trends and projections, summarized key impacts and identified potential response options in so-called primary sectors as defined by the NCCRP and stakeholders, namely water, agriculture and forestry, human health, marine fisheries, and biodiversity. The process attempted as far as possible to build upon past and current research and ongoing sector adaptation planning.

The basis for this **Summary for Policy Makers** (Phase 1) can be found in LTAS Phase 1 Full Technical Reports and Technical Summary. The relevant chapters of the Technical Summary and Sector specific Technical Report titles are specified in a footnote where relevant below. Information and results presented here focus on the likely impacts of climate change and relevant adaptation needs and response options for key sectors within South Africa.

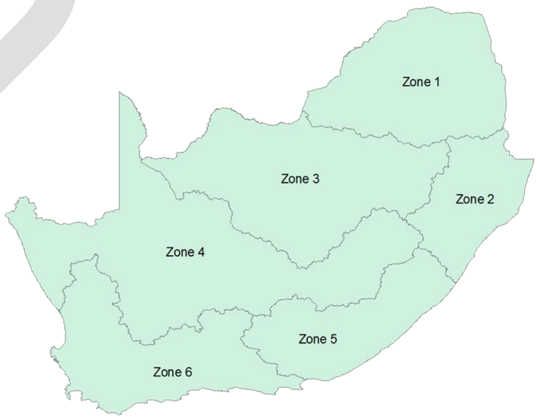


**Figure 1.** LTAS aims to provide national and sub-national adaptation scenarios for South Africa under future climates. The sub-national level covers six hydrological zones in South Africa (zone 1-6) developed for use by the National Water Adaptation Strategy process.

# Climate Trends and Scenarios for South Africa[1]

*LTAS climate scenario technical work determined the range of potential future climatic conditions that plausibly could occur in South Africa over three time frames (2015 – 2030, 2040 – 2060, and 2080 – 2100). Climate scenarios were developed in response to two emissions pathways – an unconstrained emissions pathway and a constrained (also referred to as mitigated) emissions pathway. Observed climate trends (1960 – 2012) were analysed and related to modelled trends for the same period in order to assess the possible strengths and weaknesses of modelled projections.*

## Observed Climate Trends for South Africa (1960-2012)

Over the last five decades the following climate trends have been observed in South Africa.

- Mean annual **temperatures** have increased by approximately double the observed global average of 0.7°C reported by the 4th *Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).*
- Mean and maximum temperatures have been increasing less strongly, and some decreases in minimum temperatures have been observed in the central interior.
- There have been significant overall increases in **hot extremes** and decreases in **cold extremes** particularly in the western and northern interior of the country.
- **Rainfall seasonality** has shifted and **rainfall intensity** has increased.
- In almost all hydrological zones there has been a reduction in rainfall for the autumn months. Annual rainfall has not changed significantly, but, an overall reduction in the number of rainy days implies an increase in the intensity of rainfall events and increased dry spell duration.

## Strengths and weaknesses of modelled projections (1960-2012)

*Modelled climate data were compared with observed climate trends (1960 – 2010) to explore how well climate models have simulated observed trends. Findings suggest that some key climatic processes relevant for South Africa are not yet adequately represented by either or both the General Circulation Models or the downscaling methods currently in use.*

- Observed temperature trends are more closely matched by modelled simulations than are rainfall trends.
- Observed trends since 2000 have not increased as steeply as projected by model simulations.
- The observed reductions in autumn rainfall are not reproduced by the models, and the models tend to show opposite trends.
- In spring, where observed trends are weak, models show a tendency for reduced rainfall projections in all hydrological zones.

## Projected climate Futures for South Africa (2015-2035, 2040-2060 and 2070-2090)

*Climate change projections were assessed at a national level under both the unconstrained and constrained pathways. The following climate scenarios were projected for unconstrained and constrained emission pathways respectively.*

- South Africa's climate future up to 2050 and beyond can be described using four fundamental climate scenarios at a national scale:

  1. **warmer (<4°C above 1961-2000) and wetter** with greater frequency of extreme rainfall events.
  2. **warmer (<4°C above 1961-2000) and drier**, with an increase in the frequency of drought events and somewhat greater frequency of extreme rainfall events.

1 LTAS Technical Summary Chapter 2; and Full Technical Report: Climate Trends and Scenarios for South Africa.

3. **hotter (>4°C above 1961-2000) and wetter** with substantially greater frequency of extreme rainfall events.
4. **hotter (>4°C above 1961-2000) and drier**, with a substantial increase in the frequency of drought events and greater frequency of extreme rainfall events.

- The effect of strong international mitigation responses would be to reduce the likelihood of scenarios 3 and 4, and increase the likelihood of scenarios 1 and 2 during the course of this century. These scenarios can be further elaborated in terms of rainfall projections at a sub-national level e.g. for the six hydrological zones (Table 1).

**Table 1.** Rainfall projections for each of the six hydrological zones.

| Scenario | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 |
|---|---|---|---|---|---|---|
| 1 – warmer /wetter | Increased spring and summer | Increased spring | Increased spring and summer | Increased in all seasons | Increased in all seasons | Reduced autumn, increased winter and spring |
| 2 – warmer /drier | Reduced summer, spring and autumn | Reduced spring and strongly reduced summer and autumn | Reduced summer and spring and strongly reduced autumn | Reduced summer, autumn and spring | Reduced all seasons, strongly in summer and autumn | Reduced all seasons, strongly in the west |
| 3 – hotter /wetter | Strongly increased spring and summer | Strongly increased spring | Increased spring and summer | Increased in all seasons | Strongly increased in all seasons | Reduced autumn, increased winter and spring |
| 4 – hotter /drier | Strongly reduced summer, spring and autumn | Reduced spring and strongly reduced summer and autumn | Reduced summer and spring and strongly reduced autumn | Reduced summer, autumn and spring | Reduced all seasons, strongly in summer and autumn | Reduced all seasons, strongly in the west |

## Implications for the Water Sector[2]

### Climate change impacts

- South Africa’s development options will likely be influenced by the opportunities and constraints that arise from climate change impacts on the water sector. Key decisions in development planning would benefit from considering the implications of a range of possible climate-water futures facing South Africa.

- Climate change impacts on South Africa are likely to be felt primarily via effects on water resources. Projected impacts are due to changes in rainfall and evaporation rate, but hydrological modelling approaches are essential for translating these into potential water resource impacts.

- Projected impacts include: i) a -20% to a +60% change in runoff at a national level based on an unconstrained emissions pathway; and ii) a -5% to a +20% change in runoff based on a mitigated emissions pathway. Impacts on runoff vary spatially, ranging from positive along the eastern seaboard and central interior to negative in much of the Western Cape.

- Under a wetter future scenario, trade-offs in water allocation between sectors are likely to be less restrictive, providing greater scope for urban-industrial economic growth and water provision for an intensive irrigated agricultural production model.

- Under a drier future scenario, significant trade-offs are likely to occur between developmental aspirations, particularly in terms of the allocation between agricultural and urban-industrial water use, linked to the

[2] LTAS Technical Summary Chapter 3; and Full Technical Report: The implication of climate change on water resources planning in South Africa.

marginal costs of enhancing water supply. These constraints are most likely to be experienced in Central, Northern and South-Western parts of South Africa. This scenario has significant social, economic and ecological consequences through restricting the range of viable national development pathways.

- In both wetter and drier futures, a higher frequency of flooding and drought extremes is projected, with the range of extremes exacerbated significantly under the unconstrained emissions scenario.

### Adaptation Responses and Research Requirements

- Specific provisions for climate change have not yet been made in many of the water resources reconciliation studies in South Africa, these being the primary tool for strategic water resource planning to at least 2030 in South Africa.

- Adaptation response strategies for the water sector can usefully be identified at distinct governance levels. At a **national scale**, the development of a strategic intent and enabling framework for adaptation would help to ensure a coherent national response. At a **sub-national or system scale**, key institutions could usefully engage in prioritising and allocating resources to adaptation interventions that adequately reflect the conditions at that scale. At a **sub-catchment or municipal scale**, the design of local implementation actions would be facilitated by responding to local challenges, resources and capacity.

- To build resilience to climate change in the water sector it is critical that adaptation practitioners consider responses that do not foreclose future options, develop the ability to respond to unforeseen events, monitor indicators so that changes can be observed; and adopt flexible planning to allow appropriate responses as conditions change.

- The following priority functions would be beneficial to the Department of Water Affairs: policy review for enabling flexible frameworks; flexible and robust infrastructure planning; resources directed at maintaining critical natural infrastructure in vulnerable systems; institutional oversight to ensure water-related institutions build adaptive management capacity; effective information management and maintenance of monitoring and evaluation systems; and sustainable and locally accessible financial management.

- **Research** is required for: supporting the development of tools, approaches and case studies of the way in which water planning may consider long-term climate change; understanding the way in which climate driven changes in water resources availability or demand may constrain or enable different development pathways in different parts of South Africa, particularly in terms of agricultural production and energy generation; and exploring the long-term non-stationary hydrological implications of climate change on the appropriate definition of the reserve as well as on the implications for catchment management in different systems in order to maintain the reserve.

## Implications for the Agriculture Sector[3]

### Climate change impacts

- Climate change impacts under an unconstrained emissions scenario are projected to be generally adverse for a wide range of agricultural activities by 2050 at least. Adverse impacts are projected for key cereal crop production, high value export agricultural production and intensive animal husbandry practices. Adverse impacts would also be felt through increases in irrigation demand and in the effects of agricultural pests and diseases.

[3] LTAS Technical Summary Chapter 4; and Full Technical Report: The implication of climate for the Agriculture (including forestry sector) in South Africa).

- Many of these adverse impacts would be significantly reduced under a constrained emissions scenario, with large potential avoided damages by as early as 2050.

- Under unconstrained emissions scenario, western maize production areas are likely to become less suitable for maize production. Spatial shifts in the optimum growing regions for many key crops are likely to occur (e.g. areas suitable to viticulture are likely to shrink).

- Climate change is likely to have a range of possible impacts on the yields of rain-fed crops (e.g. -25% to a +10% change on maize yield under the unconstrained pathway). It is possible that some adverse impacts will be offset by the positive impacts of higher atmospheric $CO_2$ levels, but there is no local research available to quantify this.

- Crops with strong tropical affinities, such as sugarcane, may increase in yield given the warmer/wetter projections in the tropical north-east of South Africa under the unconstrained emissions scenario. However, the annual mating index of eldana – one of the most serious sugarcane pests in South Africa – is projected to increase throughout the climatically suitable area for sugarcane by ~10% along the east coast to > 30% further inland by 2050 at least.

- Climate change-induced changes in plant and animal disease and insect distribution are also projected that would adversely affect both crop and livestock production, and animal health. Warming alone has the potential to significantly increase the area subject to damage by both chilo – a key pest of a major tropical crops and sugarcane – and codling moth – a key pest of several high value temperate fruit types, including apples, pears, walnuts and quince.

- Climate change impacts on livestock have been less studied than those on key crops. However, studies do indicate a possible increase in heat stress as a result of climate change.

- In the medium- and longer-term, the total area of potentially suitable land for commercial plantation afforestation (including *Eucalyptus*, *Pinus* and *Acacia* species) is projected to increase due to the wetting trend over the eastern seaboard and adjacent areas.

- Results generated with projected future climate scenarios over South Africa display a marked increase in thermal discomfort on more days of the year, and especially in summer months. This will have serious implications for the productivity of agricultural labour.

### Adaptation Responses and Research Requirements

- Potential adaptation responses in the agriculture sector range from national level strategies that relate for example to capacity building in key research areas, extension, and consideration of water resource allocation, all the way to the local level where responses may be specific to production methods and local conditions.

- As an overall adaptation strategy, benefits would be gained from best management practices based on the principles of the **Ecosystem Based Adaptation**[4], and **Conservation and Climate-smart Agriculture**[5]. This includes practices such as restoration and rehabilitation of ecosystems, minimising soil

[4] as defined by the Convention of Biological Diversity (CBD), "uses biodiversity and ecosystem services in an overall adaptation strategy. It includes the sustainable management, conservation and restoration of ecosystems to provide services that help people adapt to the adverse effects of climate change. EBA aims to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change

[5] as defined and presented by FAO at the Hague Conference on Agriculture, Food Security and Climate Change in 2010, contributes to the achievement of sustainable development goals. It integrates the three dimensions of sustainable development (economic, social and environmental) by jointly addressing food security and climate challenges. It is composed of three main pillars1) sustainably increasing agricultural productivity and incomes; 2) adapting and building resilience to climate change; 3) reducing and/or removing greenhouse

disturbance, maintaining soil cover, multi-cropping and integrated crop and livestock production for optimisation of yields, as well as sequestering carbon and minimising methane and nitrous oxide emissions.

- It is critical for the agriculture sector to conduct a holistic assessment of future research needs relating to climate change impacts and adaptation. Such an assessment could distinguish needs at a range of scales of implementation and identify adaptation needs for specific agricultural activities at the local scale.

- Scientific support will need to continually improve answers on the when, where, how much, what impact, and how to adapt to climate change, including reducing uncertainties on, *inter alia*, enhanced rainfall variability and its impacts on crop production; multiple year droughts and long cycle crops when farming with crops with plant cycles of 10 - 30 years (e.g. commercial timber species or deciduous fruit trees) in which case successive droughts years are critical to the survival of the trees; persistence of raindays in regard to changes in wet / wet, wet / dry, dry / dry or dry / wet sequences or fewer long duration, multiple day gentle rains in winter rainfall region being observed; number of raindays and future changes thereof in the growing season; and / or the onset and duration of the rainy season and whether it is projected to set in earlier or later.

## Implications for Human health[6]

### Climate change impacts

- Key health risks for South Africa that will be aggravated by climate change by 2050 at least include heat stress; vector-borne diseases (e.g. malaria, dengue fever and yellow fever); food insecurity, hunger and malnutrition; natural disasters; air pollution; communicable diseases (e.g. HIV/AIDS, TB and Cholera); non-communicable diseases (NCDs e.g. cardio-vascular and respiratory diseases); and mental and occupational health.

- Increases in average temperatures and episodic extreme events (e.g. heat waves) resulting from a changing climate will have increasingly significant direct impacts on human health. For example, high temperatures are known to induce heat stress and increase morbidity and mortality rates, as well as result in respiratory and cardiovascular diseases.

- Health impacts from natural disasters can be immediate (e.g. death), long-term (e.g. impacts on crop yields), direct (e.g. injuries as a result of a landslide) or indirect (e.g. changing vector abundance through habitat destruction or creation), and are difficult to project with the current knowledge base.

- An increase in the frequency/intensity of dry spells and flood events under a changing climate will result in compromised food availability, food access, and food utilisation; all of which are factors that lead to food insecurity.

- Climate change will impact air quality in South Africa by affecting weather and anthropogenic emissions and thereby negatively influencing criteria pollutants such as particulate matter (PM), sulphur dioxide, ozone, carbon monoxide, benzene, lead and nitrogen dioxide.

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gases emissions, where possible. The CSA approach is designed to identify and operationalize sustainable agricultural development within the explicit parameters of climate change (FAO, 2013).

[6] LTAS Technical Summary Chapter 5; and Full Technical Report: Climate change impacts on and adaptation responses for the Health sector under future climate change scenarios.

- Climate change can impact NCDs directly (e.g. by increasing temperatures and air pollution concentrations) and indirectly (e.g. by adversely impacting agricultural yields and resulting in food insecurity).

- Alterations in climatic factors may lead to changes in the distribution of vectors such as mosquitoes, which will change the distribution of diseases like malaria. However, malaria is more strongly impacted by non-climatic factors.

- The transmission of cholera is linked to rainfall and temperature (air and sea surface) in South Africa and, as such, it is likely that it will be affected by climate change-induced changes in rainfall and temperature regimes.

- Climate change will disrupt social and biophysical life support systems (e.g. displace communities, destroy homes, and result in loss of life). This will have serious implications on mental and occupational health (e.g. agricultural labourer's productivity) and human well-being.

### Adaptation Responses and Research requirements

- Vulnerability assessments, increased surveillance, increased access to data and multi-sectoral cooperation are critical components of adaptation strategies which feature in the South African National Climate Change and Health Adaptation Plan.

- South Africa's National Climate Change Response Policy has advocated the following adaptation measures: reducing certain criteria pollutants (e.g. sulphur dioxide); developing and strengthening existing public awareness campaigns; developing heat-health action plans; improving biosafety; developing a spatial and temporal health data capturing system; and integrating food security and sound nutritional policies into all adaptation strategies moving forward.

- Models and/or methodologies exist to begin projecting the impacts of climate change on some of South Africa's key health risks, in particular heat stress, cholera and malaria, with the modelling of the latter being the most robust. However, the relationship between climate change impacts and key health risks is not yet well-understood for South Africa.

- Research is not yet at a stage where the health impacts stemming from climate change can be accurately projected. Non-climatic factors need to be considered in such projections as these factors play a significant role in the transmission/spread of the disease.

## Implications for the Marine Fisheries Sector[7]

### Climate change impacts

- Climate change – particularly changes in sea surface temperature, storm frequency, freshwater flow and runoff patterns, oxygen levels and wind – will impact the productivity and diversity of fisheries by changing the suitability of different habitats, impacting estuary functioning, affecting fish behaviour and physiology, influencing fish size, and could result in increased fish mortalities.

- Shifts in the spatial distribution of several marine species as a result from climate variability and change have already been recorded along South Africa's coastline.

[7] LTAS Technical Summary Chapter 6; and Full Technical Report: Climate change impacts on and adaptation responses for the Marine Fisheries sector under future climate change scenarios.

- Overexploited species (such as many of the temperate linefish species) – due to their existing vulnerability to environmental changes – will be more sensitive to climate change effects than unexploited and optimally exploited species.

- Reduced/increased freshwater flow, sea level rise and increased storm activity will reduce estuarine nursery habitat; and decreased rainfall may cause temporarily open/closed estuaries to close more frequently and may even result in closure of permanently open estuaries.

- Increased storm activity under a changing climate will significant impact on fishing activity by reducing the number of viable sea fishing days; and damaging shore-based off-loading facilities and fishing vessels.

- There may also be positive climate change impacts on fisheries such expansions of the optimal range available to particular species and increasing productivity by increasing upwelling. This could result in new fishing opportunities as commercially valuable species potentially enter new areas and become available for harvest.

### Adaptation Responses and Research Requirements

- Adaptation strategies would benefit by including sound integrated ecosystem based management practices and by focusing on minimising the impacts of overfishing, habitat degradation and pollution; ensuring a sufficient area of different habitat types and resources; and maximising on maintaining strong genetic potential in fisheries.

- Maintaining genetic variability through sustainable fishing practices and appropriately zoned fishing areas including climate resilient Marine Protected Areas can secure strong genetic potential and enable adaptation to changing conditions. Fisheries that are successfully managed to achieve resource sustainability will be better positioned in the long term to adapt to the effects of climate change.

- Adaptation measures for the communities reliant on fisheries for food and income should consider mechanisms and processes to balance social and economic objectives. Adaptation options such as education, entrepreneurial training, and training in tourism and aquaculture should be promoted to prevent the potential deterioration of social conditions associated with fisher communities.

- At present, there is limited work being conducted on the impact of climate change on South African fisheries. South Africa needs to strengthen the science-base for the detection and prediction of changes and provide advice to support climate change adaptation. Research is needed to develop predictive capacity, support early detection of change and contribute to the development of mitigation and adaptation measures.

- Impacts on fisheries depends on distinct oceanographic scenarios dominated either by projected changes in southerly and westerly winds, or by changes in the strength of the Agulhas current. There are currently no regional oceanographic models at a stage of development that could reliably inform future scenarios for South African marine areas due to climate change. Furthermore, the effects of ocean acidification on fisheries and marine biodiversity remain a poorly quantified risk.

## Implications for the Biodiversity Sector[8]

### Climate change impacts

- Climate change and rising atmospheric $CO_2$ will change the suitability of the environment for South Africa's nine different biome types, with some biomes thriving and expanding under the changing

[8] LTAS Technical Summary; and Full Technical Report: Vulnerability assessment of climate change impacts on South African Biomes.

conditions and other biomes shrinking as a result. The adverse impacts of climate change on South Africa’s biomes will be exacerbated by loss of habitat driven by land use change.

- Combining the threats of climate change, rising atmospheric $CO_2$ and land use change, the **Grassland** and **Indian Ocean coastal belt** biomes are most vulnerable and require the greatest level of protection (*highest priority*). This is followed by **Fynbos** and **Forest** (*high priority*); and **Nama Karoo** and **Succulent Karoo** (medium priority).

- The **Grassland** biome has already declined in coverage by more than 60% over the past two centuries due to land use change. It is most strongly threatened by climate change which contributes to the spread of woody plants (enhanced by increasing $CO_2$ levels). Grassland areas also face considerable ongoing loss of habitat due to land use change.

- The **Indian Ocean coastal belt biome requires** urgent intervention to preserve the few intact areas of this biome. It is most strongly threatened by loss of habitat. In addition, climate change presents a considerable threat to this biome.

- The **desert biome** is projected to expand under all climate scenarios.

- Projections for indigenous bird species suggest that significant shifts in the distribution of species can be expected under the unconstrained emissions scenario by 2050 at least.

### Adaptation Responses and Research Requirements

- Two key adaptation response types are appropriate to all biomes: ecosystem-based adaptation (EBA) and biodiversity stewardship. Appropriate planning responses for each biome, i.e. Biome Adaptation Plans, and their implementation, would contribute to building climate resilience at the biome level, and to providing key support to adaptation in other sectors such as water and agriculture via ensuring continued supply of ecosystem services.

- Monitoring of key species and ecosystem changes at national, sub-national and local scales would be of great value to building a better understanding of the rate and pattern of change already observed as underway in species and ecosystems.

- Research efforts are urgently needed to support the interpretation of monitoring results of biodiversity and ecosystem change, to attribute change to the appropriate drivers, and to develop a more sophisticated national capacity to model impacts more credibly.