CLIMATE TRENDS AND SCENARIOS

Climate and Impacts Factsheet Series, Factsheet 2 of 7

THE LONG-TERM ADAPTATION SCENARIOS FLAGSHIP RESEARCH PROGRAMME (LTAS) FOR SOUTH AFRICA

The 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. This will be used to inform key decisions in future development and adaptation planning.

The first phase, completed in June 2013, developed a consensus view of climate change trends and projections for South Africa. It summarised key climate change impacts and potential response options identified for primary sectors, namely water, agriculture and forestry, human health, marine fisheries, and biodiversity.

The second phase will use an integrated assessment approach and model to develop adaptation scenarios for future climate conditions using the information, data and models from Phase 1 and inputs from a range of stakeholder consultations and task-team workshops.

The **Climate and Impacts Factsheet Series** has been developed to communicate key messages emerging from LTAS Phase 1; and to complement the LTAS Phase 1 technical reports and the summary for policy-makers.

This factsheet has been developed specifically to provide policy- and decision-makers, researchers, practitioners and civil society with up-to-date information on observed climate trends and projected climate scenarios over the short- (2015–2035), medium- (2040–2060) and long-term (2070–2090) for South Africa. For further details see the LTAS Phase 1 full technical report entitled *Climate Trends and Scenarios for South Africa.*

1. Introduction

The climate trends and scenarios work done in LTAS Phase 1 is the most significant step thus far in consolidating relevant data for South African climate change modelling (see Box 1). The process engaged with local and international climate modellers to develop a consensus set of climate scenarios for South Africa representing different future global emissions pathways. This included downscaling global climate models from the fourth and fifth assessment reports (AR4 and AR5) of the Intergovernmental Panel on Climate Change (IPCC); and exploring short-term scenarios for the time period 2015 to 2035 (centred on ~2025), in addition to the medium and long term scenarios previously explored (centred on ~2050 and ~2090 respectively). The process also compared observed climate trends for South Africa from 1960 to 2010 to modelled trends for the same period to begin identifying possible strengths and weaknesses in the current modelling approaches. Due to the variety of emissions scenarios employed by climate modellers in the projections, the LTAS process has attempted to gather these into two main groups, namely unmitigated (unconstrained) and mitigated (constrained) future energy pathways (see Box 1, final bullet).

BOX 1. PROGRESSION OF WORK ON CLIMATE CHANGE SCENARIOS FOR SOUTH AFRICA

- **1990s:** The South African Country Studies Programme developed a series of climate projections (including a simple interpolation of global climate models and statistically downscaled projections) in preparation for South Africa's Initial National Communication for submission to the United Nations Framework Convention on Climate Change (UNFCCC).
- **2003, South Africa's Initial National Communication:** The overall view was that South Africa faced a considerably drier and warmer future by mid-century, with some indication of an increased risk of intense rainfall events.
- **2003–2007:** Modelling approaches developed extensively internationally, including improved representation of oceanic influences on global and regional climates. In South Africa and the broader region, downscaling methods were applied far more extensively than before.
- **2007, Fourth Assessment Report (AR4) of the IPCC:** High levels of uncertainty relating to rainfall projections in the summer rainfall regions of South Africa, while the winter rainfall region continued to show a higher likelihood of drying than wetting by mid- to end-century.
- **2011, South Africa's Second National Communication:** Statistical downscaling of AR4 results showed a far higher likelihood of increased rainfall over the summer rainfall eastern regions of South Africa, however, the impacts of rising temperature would lead to a net decrease in water availability in many (but not all) regions.

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Table 1. Rainfall projections for each of South Africa's six hydrological zones.

Scenario	Limpopo/Olifants/ Inkomati	Pongola-Uzimkulu	Vaal	Orange	Mzimvubu-Tsitsikamma	Breede-Gouritz/ Berg
1: warmer/ wetter	↑ spring and summer	↑ spring	↑ spring and summer	↑ in all seasons	↑ in all seasons	↓ autumn, ↑ winter and spring
2: warmer/ drier	↓ summer, spring and autumn	↓ spring and strongly ↓ summer and autumn	↓ summer and spring and strongly ↓ autumn	↓ summer, autumn and spring	↓ in all seasons, strongly ↓ summer and autumn	↓ in all seasons, strongly ↓ in the west
3: hotter/ wetter	Strongly ↑ spring and summer	Strongly ↑ spring	↑ spring and summer	↑ in all seasons	Strongly ↑ in all seasons	↓ autumn, ↑ winter and spring
4: hotter/ drier	Strongly ↓ summer, spring and autumn	↓ spring and strongly ↓ summer and autumn	↓ summer and spring and strongly ↓ autumn	↓ summer, autumn and spring	↓ all seasons, strongly ↓ in summer and autumn	↓ all seasons, strongly ↓ in the west

5. Projected climate futures for South Africa (2015–2035, 2040–2060 and 2070–2090)

South Africa's climate future up to 2050 and beyond can be described using four fundamental climate scenarios at national scale, with different degrees of change and likelihood that capture the impacts of global mitigation and the passing of time.

1. warmer (<3°C above 1961–2000) and wetter with greater frequency of extreme rainfall events.
2. warmer (<3°C above 1961–2000) and drier, with an increase in the frequency of drought events and somewhat greater frequency of extreme rainfall events.
3. hotter (>3°C above 1961–2000) and wetter with substantially greater frequency of extreme rainfall events.
4. hotter (>3°C above 1961–2000) and drier, with a substantial increase in the frequency of drought events and greater frequency of extreme rainfall events.

Effective international mitigation responses would reduce the likelihood of scenarios 3 and 4, and increase the likelihood of scenarios 1 and 2 during this century. In both wetter and drier futures a higher frequency of flooding and drought extremes could be expected, with the range of extremes significantly increased under unconstrained emissions scenarios. Table 1 gives rainfall projections for these scenarios for South Africa's six hydrological zones.

Climate change projections for South Africa up to 2050 and beyond project warming as high as 5–8°C over the South African interior, and somewhat less over coastal regions, under an unmitigated global emissions scenario. A general pattern of a risk of drier conditions to the west and south of the country and a risk of wetter conditions over the east of the country has been projected, but many of the projected changes are within the range of historical natural variability. These rainfall projections are associated with a high degree of uncertainty.

Global climate model ensembles summarised for South Africa suggest a significant benefit from effective mitigation responses (global CO_2e stabilisation at between 450 and 500 ppm) relative to unconstrained emission pathways by as early as mid-century. Effective global mitigation efforts would halve median warming at the regional level from just under 2°C to about 1°C by as early as 2050, and would reduce the risk of high regional warming and extreme changes in rainfall.

Even under effective international mitigation responses, significant socio-economic implications are expected for vulnerable groups and communities in South Africa under both wetter and drier climate futures. These implications would largely be felt through impacts on water resources, such as changes in water resource availability and a higher frequency of natural disasters (flooding and drought), with cross-sectoral effects on human settlements, disaster risk management and food security.

6. Conclusions and linkages

Over the last five decades significant changes in climate have been observed in South Africa. Mean annual temperatures have increased by about 1.5 times the observed global average of 0.65°C, and hot and cold extremes have increased and decreased respectively in frequency. In almost all hydrological zones there has been a tendency towards reduced rainfall for the autumn months, though annual rainfall has not changed significantly. Instead there has been an overall reduction in the number of rainy days, implying a tendency towards an increase in the intensity of rainfall events and increased dry spell duration.

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- **2011–2013:** Higher resolution dynamic and statistical downscaling of IPCC AR4 results developed over southern Africa, using mainly A2 and B1 emissions scenarios. Plausible climate scenarios included reduced rainfall over the south-western Cape and more frequent occurrence of mid-level anti-cyclones between spring and autumn, resulting in the southern African region becoming generally drier.
- **2013, Fifth Assessment Report (AR5) of the IPCC:** A new set of emissions scenarios and global climate scenarios developed by the international community, for example the Representative Concentration Pathways (RCPs), four greenhouse gas concentration trajectories describing four possible climate futures and used for climate modelling and research.
- **2013, LTAS Phase 1:** Future climate trends simulated over southern Africa using both statistical and dynamic downscaling of the output of AR4 (A2 and B1 emissions scenarios) and AR5 (RCPs 8.5 and 4.5) representing unmitigated (A2 and RCP8.5) and mitigated (B1 and RCP4.5) future energy pathways. In addition, a pattern scaling method using a two dimensional atmospheric model of the MIT Integrated Global System Model was used that employed 450ppm CO_2 stabilisation as a mitigated scenario, contrasted with an unmitigated pathway. Four fundamental climate scenarios were developed for South Africa nationally, and further elaborated at sub-national level, up to 2050 and beyond.

The LTAS presents climate trends and projections at national scale, and for the six hydrological zones of South Africa developed for the National Water Adaptation Strategy process, namely zone 1: the Limpopo, Olifants and Inkomati water management areas (WMAs) in the northern interior (Limpopo/Olifants/Inkomati); zone 2: the Pongola-Umzimkulu WMA in KwaZulu-Natal in the east (Pongola-Uzimkulu); zone 3: the Vaal WMA in the central interior (Vaal); zone 4: the Orange WMA in the north-west (Orange); zone 5: the Mzimvubu-Tsitsikamma WMA in the south-east (Mzimvubu-Tsitsikamma); and zone 6: the Breed-Gouritz and Berg Olifants WMA in the south-west (Breed-Gouritz/Berg) (see Box 2).

BOX 2. HYDROLOGICAL ZONES IN SOUTH AFRICA

Climate change impacts across South Africa will be mediated through primary impacts on the water sector. Six hydrological zones have been developed as part of the National Water Adaptation Strategy process, reflecting boundaries defined by water management areas (WMAs) in South Africa, and grouped according to their climatic and hydrological characteristics. These zones can be appropriately modelled and analysed for direct impacts on the water sector, and related indirect effects on other sectors.

2. Observed climate trends for South Africa (1960–2010)

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

- Mean annual temperatures have increased by more than 1.5 times the observed global average of 0.65°C reported by the 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) for the period from 1950.
- Maximum and minimum temperatures have been increasing annually, and in almost all seasons. A notable exception is the central interior (zone 3; Vaal), where minimum temperatures have been increasing less strongly, and some decreases have been observed.
- Hot and cold extremes have increased and decreased respectively in frequency, in most seasons across the country, particularly in the western and northern interior.
- In almost all hydrological zones there has been a marginal reduction in rainfall for the autumn months. Annual rainfall has not changed significantly, but an overall reduction in the number of rain days implies a tendency towards an increase in the intensity of rainfall events and increased dry spell duration.
- Extreme rainfall events show a tendency towards increasing in frequency annually, and especially in spring and summer, with a reduction in extremes in autumn.

3. Strengths and weaknesses of model simulations of recent historical climate (1960-2010)

Some key climatic processes relevant for South Africa may not yet be adequately represented by the General Circulation Models (GCMs) used to model global climate or the downscaling methods being used. Key findings are:

- Modelled simulations more closely match observed temperature trends than rainfall trends.
- Observed trends since 2000 have not increased as steeply as modelled projections, a tendency noted in the IPCC 5th Assessment Report.
- Observed temperature has not changed significantly in the central interior (zone 3, Vaal), but modelled trends are significantly positive, matching all the other zones.
- The models do not reproduce observed reductions in autumn rainfall and tend to show opposite trends.

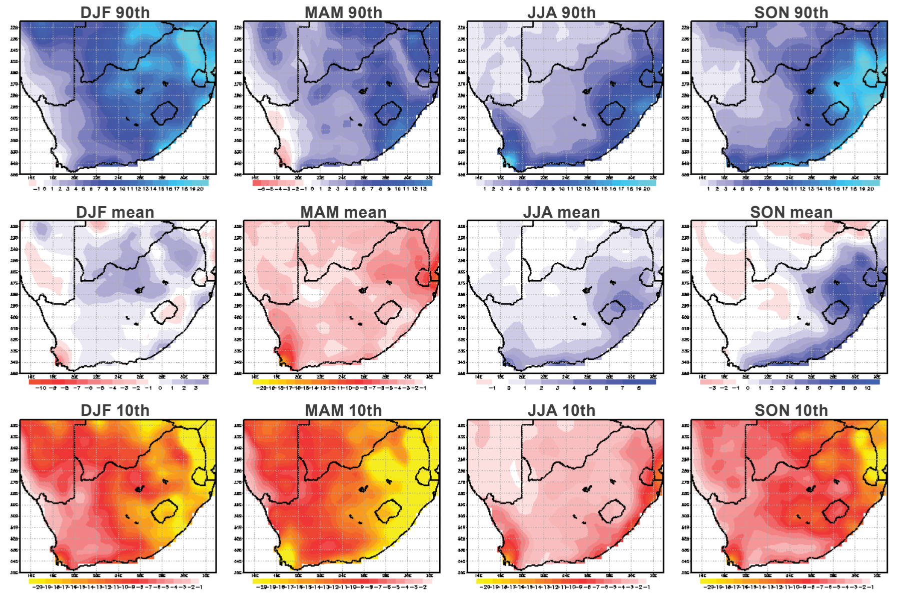

Figure 1. Projected changes, using a statistical downscaling method, in seasonal rainfall for the end of this century (2075–2095) under RCP8.5 for summer: December, January, February (DJF); autumn: March, April, May (MAM); winter: June, July, August (JJA); and spring: September, October, November (SON). Results are expressed as monthly mean rainfall anomalies. The middle row of panels represents the mean projected change, the upper row the 90th percentile (wetter), and the lower row the 10th percentile (drier). In other words, there is an 80% likelihood that the projected change would lie between the lower and upper panels according to this set of projections.

4. Projected rainfall and temperature changes for South Africa (to 2050 and beyond)

Climate change projections for South Africa up to 2050 and beyond under the Special Report on Emissions Scenarios (SRES) A2 and the RCP8.5 unmitigated emissions scenarios (see Box 3) (based on statistical and dynamical downscaling of the scenarios), include:

- Significant warming, as high as 5–8°C, over the South African interior (under RCP8.5). This warming would be somewhat reduced over coastal zones.
- A general pattern of a risk of drier conditions to the west and south of the country and a risk of wetter conditions over the east of the country.
- Many of the projected changes are within the range of historical natural variability, and uncertainty in the projections is high (see Figure 1).

BOX 3. UNCONSTRAINED/UNMITIGATED VERSUS CONSTRAINED/MITIGATED EMISSIONS SCENARIO

- Unconstrained/unmitigated emissions pathway/scenario represents a future whereby CO_2e levels are higher than 500 ppm by mid-century. These include the Intergovernmental Panel on Climate Change (IPCC) Assessment Report 4 Special Report on Emissions Scenarios (SRES) A2 scenario and the Assessment Report 5 Representative Concentration Pathway (RCP) 8.5 scenario.
- Constrained/mitigated emissions pathway/scenario represents the effect of effective international mitigation responses equivalent to CO_2e levels stabilising between 450 ppm and 500ppm. These include the IPCC AR4, SRES-B1 and AR5, RCP4.5 scenario.

The risk of extreme rainfall changes, both increases and decreases, would be reduced by 2050 by an effective global emissions reduction pathway (for example under the SRES B1 and RCP4.5 mitigated emission scenarios). High resolution regional modelling supports this finding for 2050, and suggests even larger benefits from effective global mitigation by the end of this century, when regional warming of 5–8°C (projected under RCP8.5) could be more than halved to 2.5–3°C (under RCP4.5). Although the mitigated emissions scenarios reduce the extreme outcomes projected under higher emission scenarios, the spatial pattern of change remains similar. All modelling approaches project warming trends until the end of this century, but most approaches project the possibility of both drying and wetting trends in almost all parts of South Africa.