

CLIMATE

RISK AND VULNERABILITY

A HANDBOOK FOR
SOUTHERN AFRICA

EXECUTIVE SUMMARY

2nd Edition

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CLIMATE RISK AND VULNERABILITY

A HANDBOOK FOR SOUTHERN AFRICA

Executive Summary

Progress made in understanding future climate change provides an increasingly robust basis for policy development.

Climate change is acknowledged by the United Nations as the defining human development challenge of the 21st century. The 2nd edition of the “Climate Risk and Vulnerability Handbook for Southern Africa” presents the latest available scientific knowledge on the nature of climate change and its implications for the region. The handbook serves as an important guide for climate and development practitioners, students, researchers, and policy-makers. This summary provides an accessible and southern Africa-specific overview of evidence for climate change, projected future climates, potential impacts across sectors, and responses to reduce risk (adaptation and disaster risk reduction).

KEY MESSAGES

CLIMATIC CHANGES



Southern Africa has been **warming significantly** over the last century. For the period 1961 to 2014 temperatures over the region have increased at a rate of 0.4 °C per decade.



Warmer conditions are likely over most of the interior of southern Africa in the future, with more frequent very hot days (> 35 °C).



High year-to-year rainfall variability is typical in the region, and there is little evidence for a substantial drying or wetting to date.

In the future, **a decrease in rainfall is projected over central southern African** (e.g. northern Botswana, Namibia, southern Zambia and Zimbabwe) and over the southwestern Cape of South Africa. **An increase in rainfall is projected over northern Mozambique and Tanzania.**

IMPACTS



Over the past four decades (1980-2016) **weather-related disasters in SADC** have resulted in damages in the region of 10 billion USD, have left 2.47 million people homeless and affected a further 140 million people.



Vulnerability to climate change is not only caused by the level of exposure, but also by social, economic and other environmental factors that interact with the changing climate.



SECTOR IMPACTS

The risks posed by climate change will likely result in a **range of negative impacts across the region**, many of which are cross-cutting through key sectors. With appropriate responses, climate change need not always be detrimental, and proactive responses can exploit opportunities for climate-resilient development.



RESPONDING TO CLIMATE CHANGE



Integrating **climate change adaptation and disaster risk reduction** through a risk management approach will help to reduce future losses from climate extremes.



Enabling synergies among mitigation and adaptation actions is required to support sustainable development and the creation of more efficient, responsive and comprehensive climate policies.



The **transboundary nature** of climate change necessitates regional cooperation and action.



There are **increasing resources available to respond to climate change** through various mechanisms, such as the Green Climate Fund.

1 EVIDENCE FOR CLIMATE CHANGE

Observational records show that **temperatures** in the region have been increasing over the last century and that the rate of warming has been increasing – most notably in the last two decades. For the period 1961 to 2014, temperatures over the region have increased at a rate of 0.4 °C per decade (Figure 1). Temperature trends across seasons show a slightly larger warming in summer (December-January-February) and autumn (March-April-May) compared with the other seasons. These observed increases in land surface temperatures have occurred simultaneously with increases in **evapotranspiration** across the region.

Trends in **sea surface temperatures** (SST) demonstrate warming at all latitudes along the entire southern African coastline. Changes in SST have important implications for the upwelling strength in the Benguela Current system as well as the Agulhas Current, both of which are important drivers of regional climate.

Rainfall over southern Africa is characterised by strong inter-annual and inter-decadal variability (Figure 2). These alternating patterns of above-normal/below-normal rainfall periods clearly illustrate the rainfall cycles prevalent in southern Africa where extreme wet and dry years have resulted in floods and droughts. Against this variability there is little evidence of a substantial change in mean annual rainfall (wetting or drying) over the period 1961 to 2014.

Changes in many **extreme weather events** have been observed since 1950. Some changes are evident with clear long-term trends (e.g. more frequent hot days), whilst others are more difficult to detect (e.g. tropical cyclones and thunderstorms).



Identifying (and modelling) long-term trends in rainfall over southern Africa are challenging for a number of reasons:

- Typically the region has always had variable rainfall from year to year.
- There is a shortage of observational data from weather stations to draw robust conclusions on trends.
- Rainfall is dependent on the interaction of multiple drivers, including global atmospheric patterns, influence of the warm Indian Ocean and cold Atlantic Ocean, movement of the Intertropical Convergence Zone, and the influence of the El Niño-Southern Oscillation (ENSO).



Figure 1: Observed trends in mean annual temperature (°C) over southern Africaⁱ

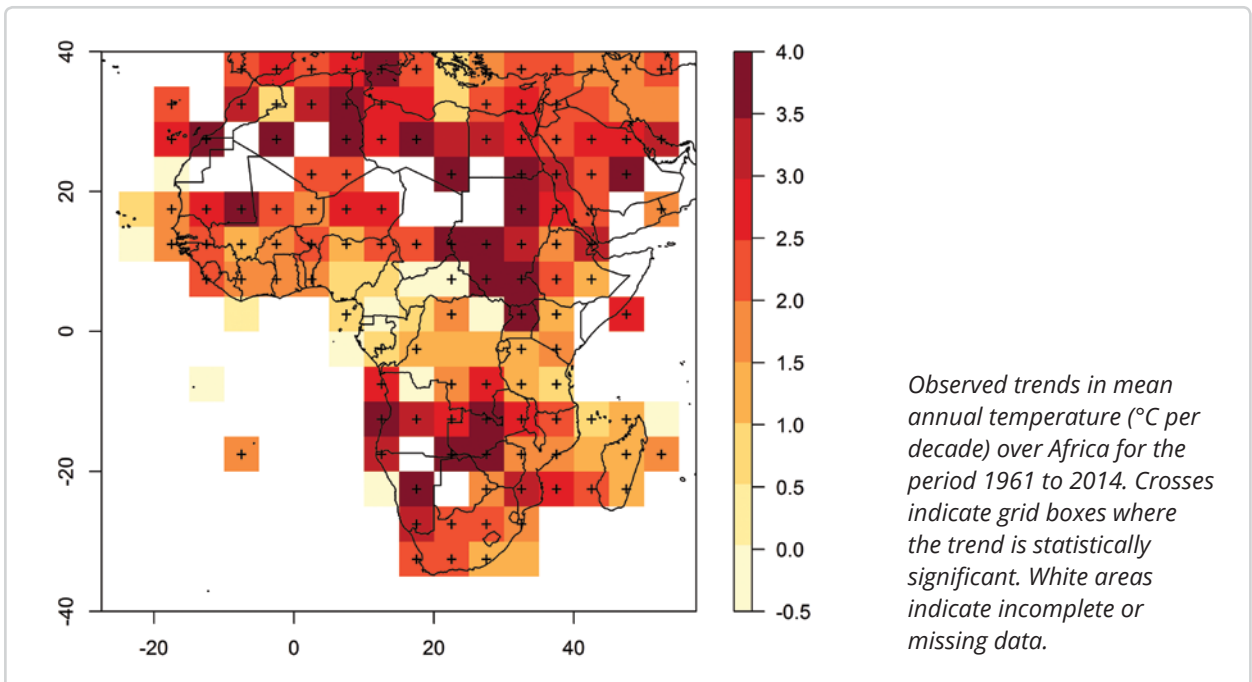
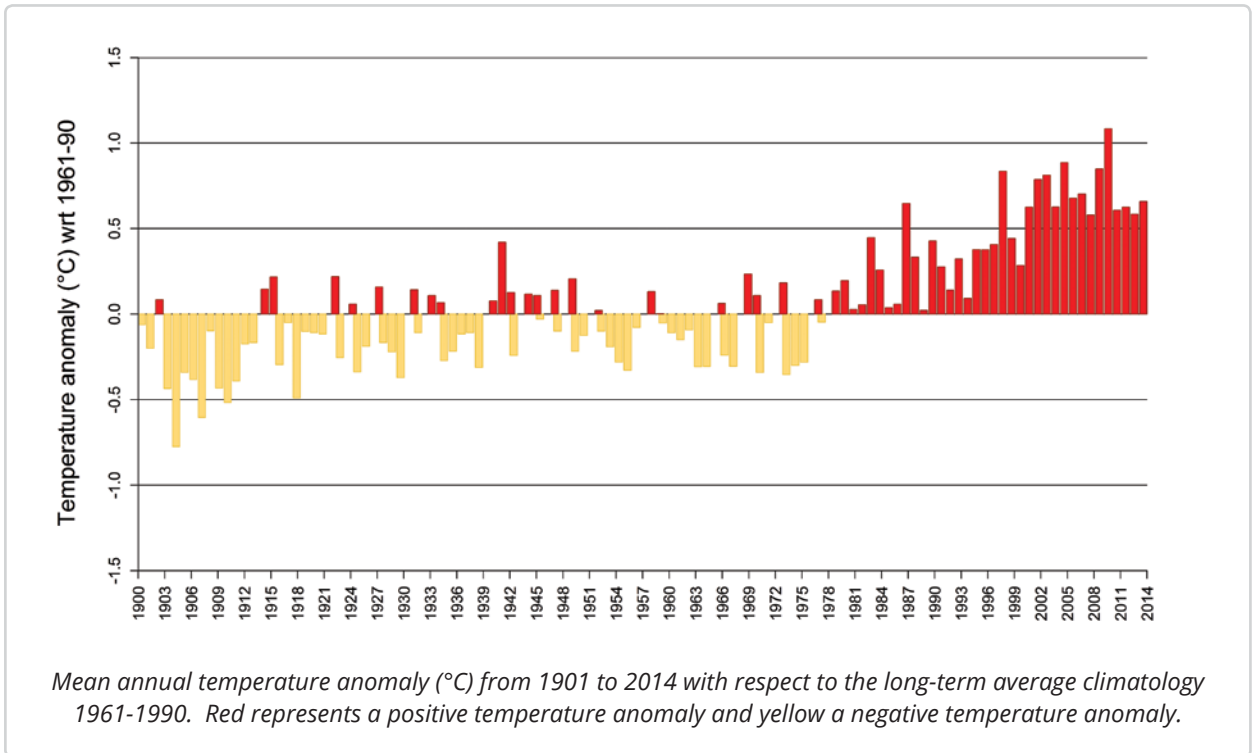
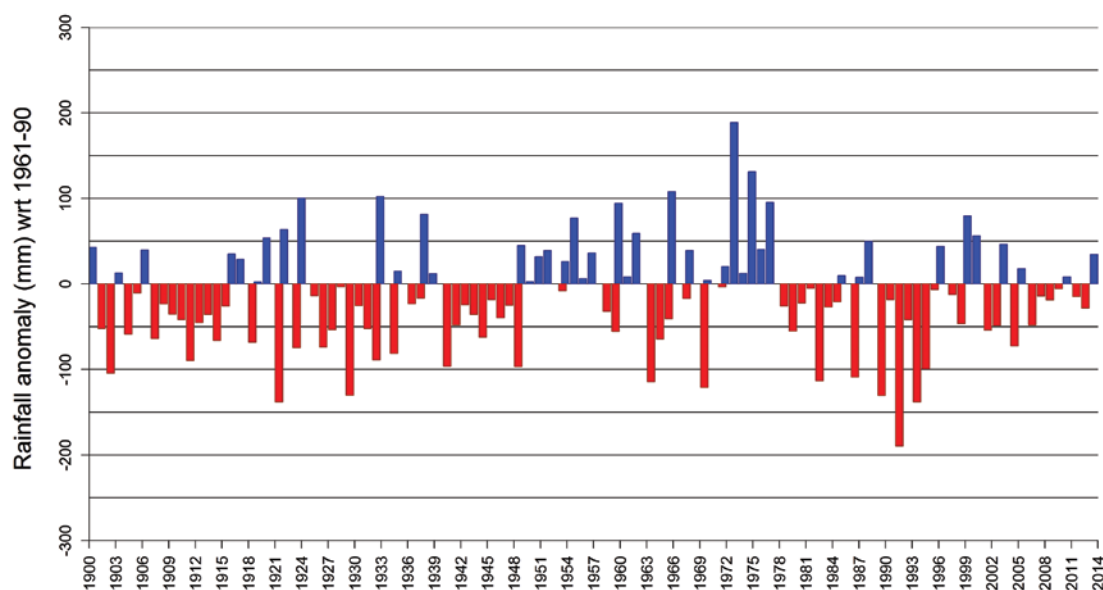


Figure 2: Observed trend in mean annual rainfall over southern Africaⁱⁱ



Mean annual rainfall anomaly (mm) over southern Africa from 1901 to 2014 with respect to the long-term average climatology 1961-1990. Blue represents a positive anomaly and red a negative anomaly in rainfall.



Determining future climate

Global Climate Models (GCMs) are the fundamental tools used to project long-term future change. These complex computer models represent interactions between the different components of the climate system, such as the land surface, the atmosphere and the oceans. GCMs typically have a very coarse resolution (100 km) and often cannot capture the physical processes and features of the landscape that are important determinants of local and regional climates. **Downscaling techniques** (statistical and dynamical) translate the changes in the large-scale atmospheric circulation to finer spatial scales.

Projected changes in climate are dependent on the future levels of greenhouse gas emissions in the atmosphere which, in turn, reflect society's behaviour and policy choices. GCMs simulate climate under a range of **emission scenarios**, each representing a plausible future. The IPCC Special Report on Emissions Scenarios (SRES) described four possible 'story lines' (A1, B1, A2 and B2), each assuming different paths of development for the world. In the IPCC Fifth Assessment Report (AR5), Representative Concentration Pathways (RCPs) replaced the SRES emission scenarios and were used as the basis of the climate projections presented in AR5.

2 PROJECTED CLIMATE FUTURES

Since the first edition of the handbook, significant progress has been made in projecting and understanding climate change for the region, providing an increasingly robust basis for strategy and policy. There is now greater consistency between projections derived using different modelling approaches, suggesting that convergence may be enhanced through the use of more GCMs and through refinement/development of modelling approaches and downscaling tools. Table 1 provides a summary of the latest projections.

Temperatures are projected to continue to increase during the 21st century, with the rate of increase reflecting the concentrations of greenhouse gases in the atmosphere. Average annual temperatures are likely to increase by 1-3 °C by 2050, with higher increases expected during summer months. Warming is likely to be greatest towards the interior of the region, and lower in coastal areas.

Projected changes in **rainfall** vary more, due to differences in the ability of climate models to replicate observed rainfall patterns and simulate rainfall-producing processes. However, there is agreement between models that central southern Africa

(e.g. northern Botswana, Namibia, the southwestern Cape of South Africa, southern Zambia and Zimbabwe) is likely to be drier, with Tanzania and parts of northern Mozambique projected to be wetter in the future.

Climate change is projected to alter the frequency and intensity of some extreme events in the future. Projections based on dynamical downscalingsⁱⁱⁱ suggest that the annual frequency of **very hot days** (number of days when the maximum temperature exceeds 35 °C) will increase and that the frequency of **extreme rainfall events** (20 mm or more of rain falling within 24 hours) will increase over the eastern parts of southern Africa.

Based on information from the IPCC Special Report in Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) and IPCC Fifth Assessment Report (AR5), projected increases in extreme temperatures combined with dry spells may increase the risk of **wildfires**. Coastal **storm surges** are expected to increase as a result of sea level rise. Higher sea levels will mean that smaller storms are likely to have an increased impact on the coastline.





Evaluating the outputs of GCMs

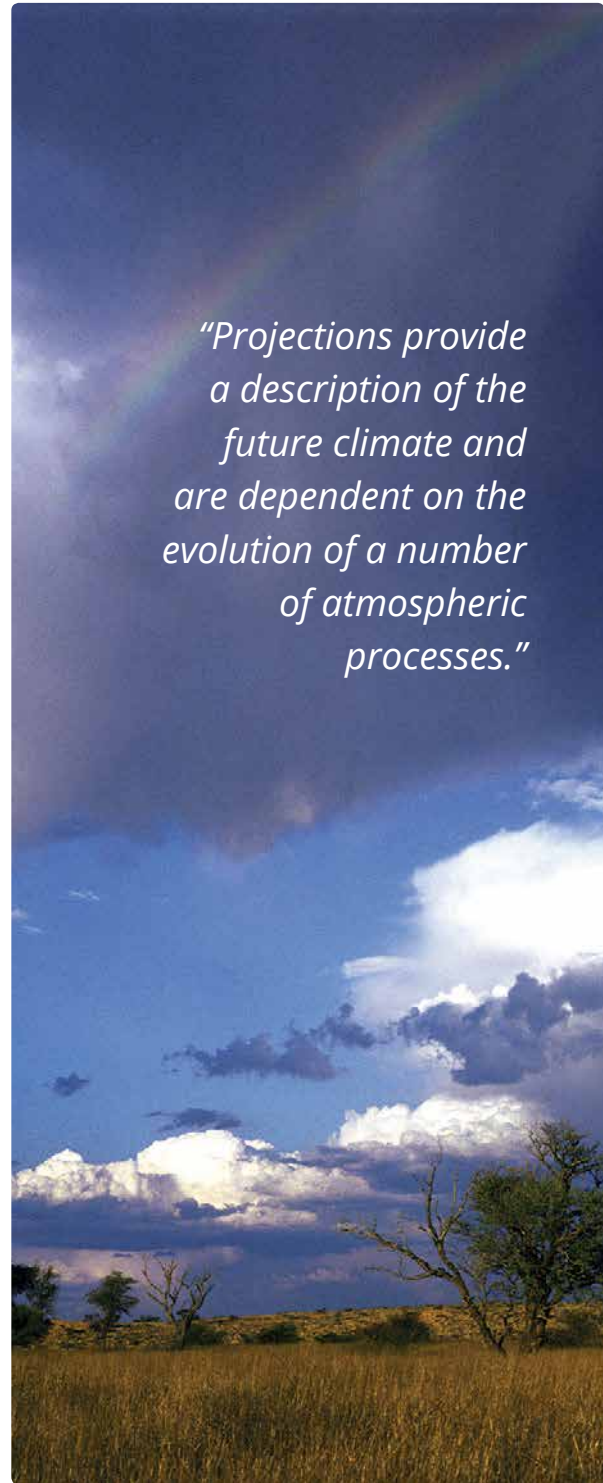
Choosing the single ‘best’ GCM is problematic as future scenarios are all linked to the representation of physical and dynamical processes within that specific model. Using one model may create a false degree of confidence in its projection. Projections are more robust if they are made from outputs of several models (known as an ensemble) that use the same emission scenario (e.g. RCP 4.5).

Using this ensemble approach, future change might be expressed as a narrative of potential changes (e.g. wetter and hotter) or as a range of projected changes, with some measure or recognition of the spread of possible future climates.



Using climate change projections for planning

Downscaled projections are increasingly being used in studies of regional impacts and adaptation. A common misconception is that high-resolution or downscaled projections are better than the coarser projections from GCMs. Although downscaled simulations are, in theory, expected to provide a more accurate representation of regional climate and its expected future change, the higher resolution offered by these simulations does not necessarily mean higher confidence in the projections. This is because the performance of downscaling techniques is highly dependent on the quality of the input data and this means that downscaled data may inherit assumptions and errors in the GCM simulations.



“Projections provide a description of the future climate and are dependent on the evolution of a number of atmospheric processes.”

Table 1: Summary and comparison of climate change projections from the GCMs and the two downscaling techniques

	GCM	Statistical downscalings	Dynamical downscalings
Temperature 			
	Increase in mean, maximum and minimum temperatures		
Rainfall 			
	Increase in rainfall over Tanzania and parts of northern Mozambique		
			
	Decrease over central southern Africa (e.g. northern Botswana, Namibia, southern Zambia and Zimbabwe) and southwestern Cape of South Africa.		
Extreme temperatures 		Not available	
	Increase in very hot days and heat waves		Increase in very hot days – above 35 °C
Heavy rainfall 		Not available	
	Low confidence that heavy rainfall events will increase		Increase in the frequency of extreme rainfall events (20 mm of rain falling within 24 hours) over eastern parts of southern Africa
Droughts 		Not available	Not available
	Medium confidence that droughts will intensify		

The black arrows (⬆️) indicate high confidence in projected change, with all model ensembles indicating the same directional change (e.g. increase in temperature). The grey arrows (⬆️) indicate some agreement between models, but there is less confidence in those projections.

3 EXTREME WEATHER EVENTS

Southern Africa is susceptible to a number of extreme weather events particularly floods, droughts, wildfires and large storms^{iv} (Figure 3). The impacts range from primary (or direct) effects, such as damage to infrastructure and death, to secondary (or indirect) effects, such as increasing health burden and the loss of livelihoods. An analysis of the socio-economic impacts from recent extreme climate events reveals significant vulnerability and exposure of the region that translates into climate-related disasters.

Over the past four decades (1980-2015), the Southern African Development Community (SADC) experienced 491 recorded climate disasters^v (meteorological, hydrological, and climatological) that resulted in 110 978 deaths, left 2.47 million people homeless and affected a further 140 million people^{vi} (Figure 4).

Floods have tended to be the most frequent type of climate-related disaster, while droughts have resulted in the highest economic cost of damages and have affected

a larger proportion of the region's population (Figures 3-4). Between 1980 and 2015 an estimated 107 million people (37% of the SADC population) were affected by drought, compared to an estimated 21 million people affected by floods (8% of the SADC population). This can be attributed to the nature of droughts, which are slow in onset and tend to affect large areas. Storms have been responsible for displacing the most people, with an estimated 1.7 million people left homeless between 1980 and 2016 (Figure 3).

Commitments to proactive disaster risk management (DRM) will be required to reduce the costs of extreme weather events. Currently DRM receives only a small proportion of global development assistance, and the amount allocated to proactive risk reduction, as opposed to response (relief and rehabilitation), is still small. There is a large body of evidence that suggests that investment in disaster prevention is more cost-effective than spending on relief^{vii}.



El Niño, drought and climate change

Since droughts in southern Africa are often linked to strong El Niño conditions, an important question is whether a warmer climate will result in more frequent and more intense ENSO events. Research is underway to understand the mechanisms and consequences of climate dynamics in the region on short- to long-term time scales^{viii}. The occurrence of extreme El Niño events may double in the future as a result of greenhouse gas induced warming^{ix}.

Figure 3: Summary of impacts of climate-related events on southern Africa between 1980 and 2015

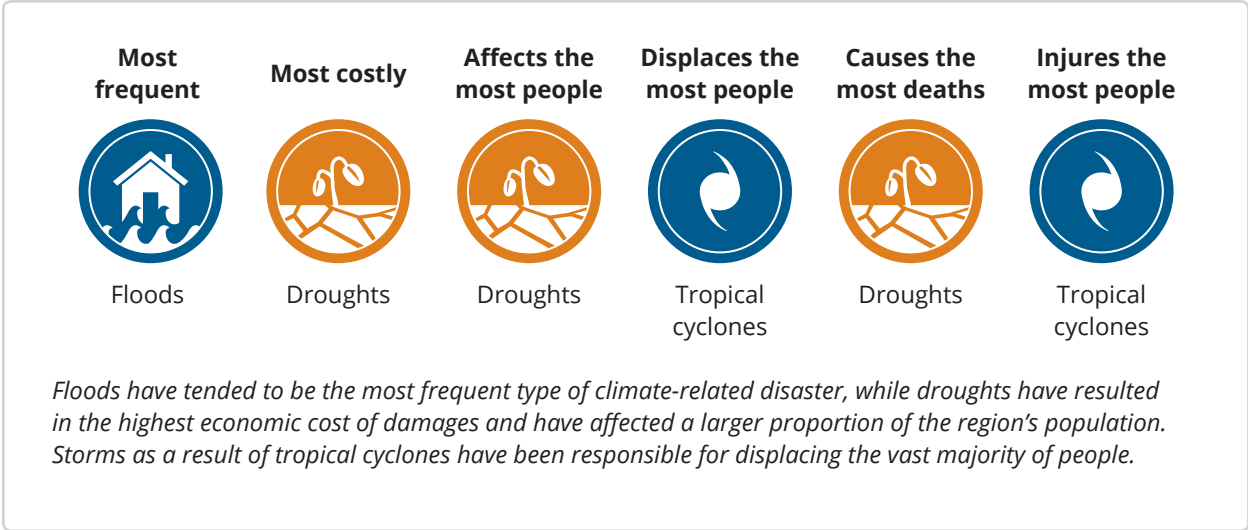
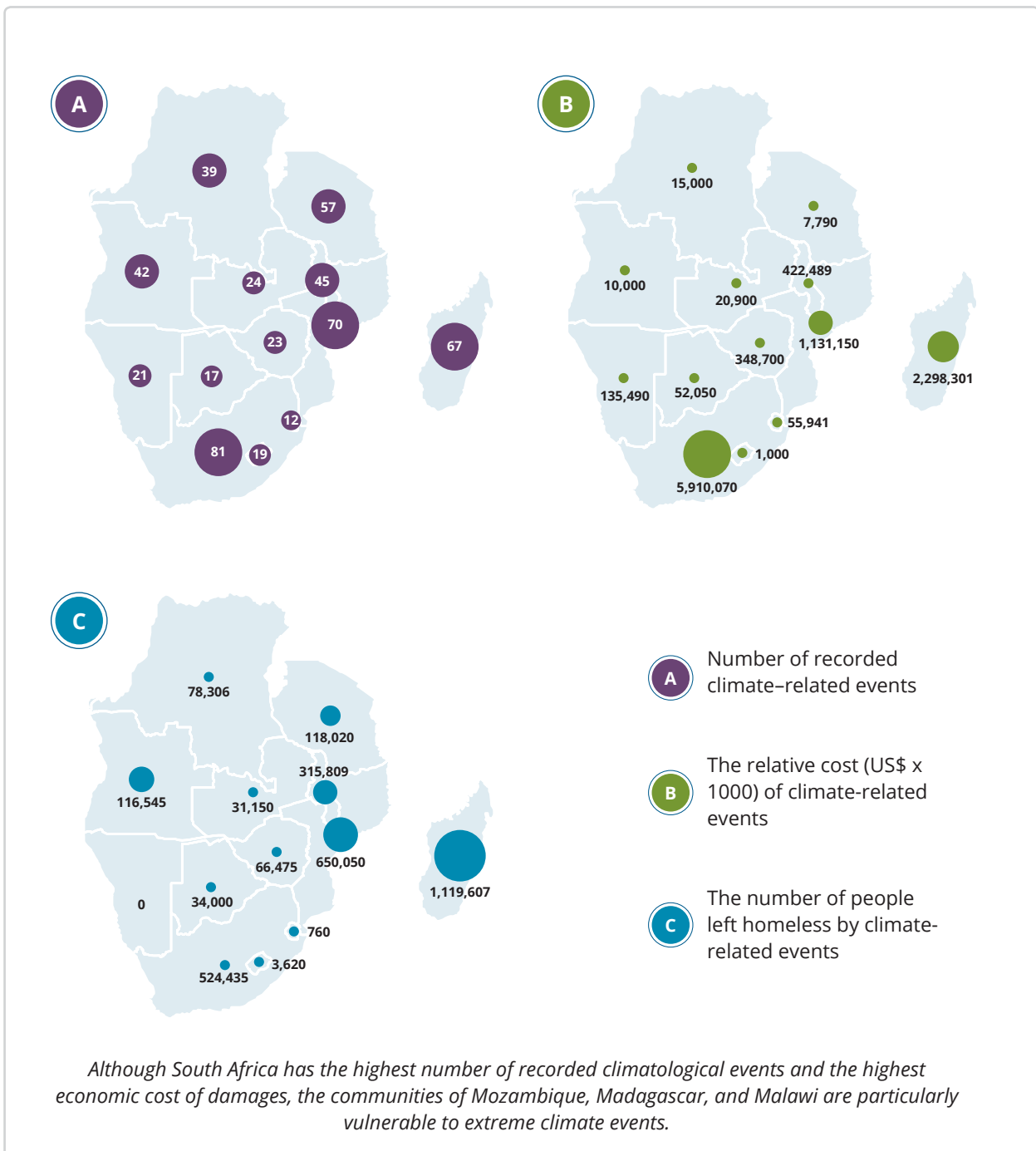


Figure 4: Summary of the climate-related events per country in southern Africa since 1980^{vi}



Tropical cyclones and climate change

Future changes in the intensity, frequency and duration of tropical cyclones are highly uncertain. Tropical cyclones are very difficult to simulate even under current climate conditions and there are large uncertainties in projected changes. The global increase in temperature and water vapour suggests a potential increase in heavy precipitation associated with tropical storms and cyclones. Further research is needed in order to better understand changes in the characteristics of tropical cyclones occurring over the southwest Indian Ocean.

4 IMPACTS OF CLIMATE CHANGE

The changing climate is likely to have a range of impacts across different sectors in the region, and understanding this is important for identifying and prioritising adaptation interventions. Determining the impacts of climate change depends on the interaction of several factors: the nature of the climate-related hazard, the exposure and vulnerability of both human and natural systems, and the social and economic factors that determine the capacity to adapt* (Figure 5).

With an urbanising population, for example, **exposure** of a city to an extreme weather event puts a larger number of people at risk of negative effects, as well as potentially larger costs due to the high value of infrastructure. High levels of **vulnerability** will transform even small-scale events into disasters for some affected communities. The increase in **hazards** under climate change means

that recurrent exposure, to even small or medium-scale events, can increase vulnerability as the negative effects are cumulative. This is increasingly observed in the agriculture sector (for example with successive years of drought).

The impacts of climate change differ from sector to sector (Figure 6). Potential impacts include increasing energy demand (in terms of achieving human comfort within buildings and factories), reductions of yield in the maize crop under higher temperatures and reduced soil moisture, higher cattle mortality as a result of heat stress, water insecurity through reduced rainfall and enhanced evapotranspiration, shifts in natural ranges of species, and damage to buildings, roads and bridges from extreme events.

Figure 5: The risk framework adopted by the IPCC in the Special Report on Extreme Events and the Fifth Assessment Report*

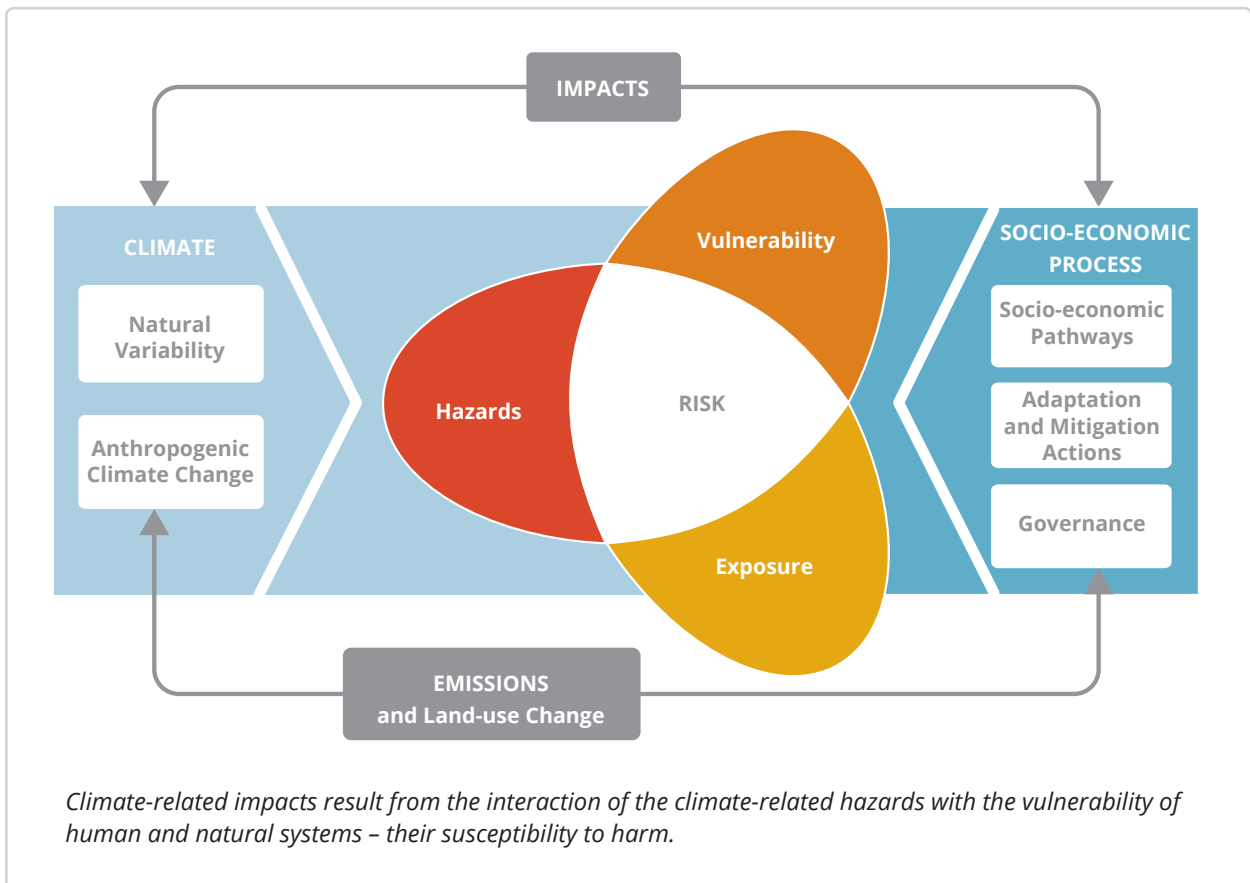
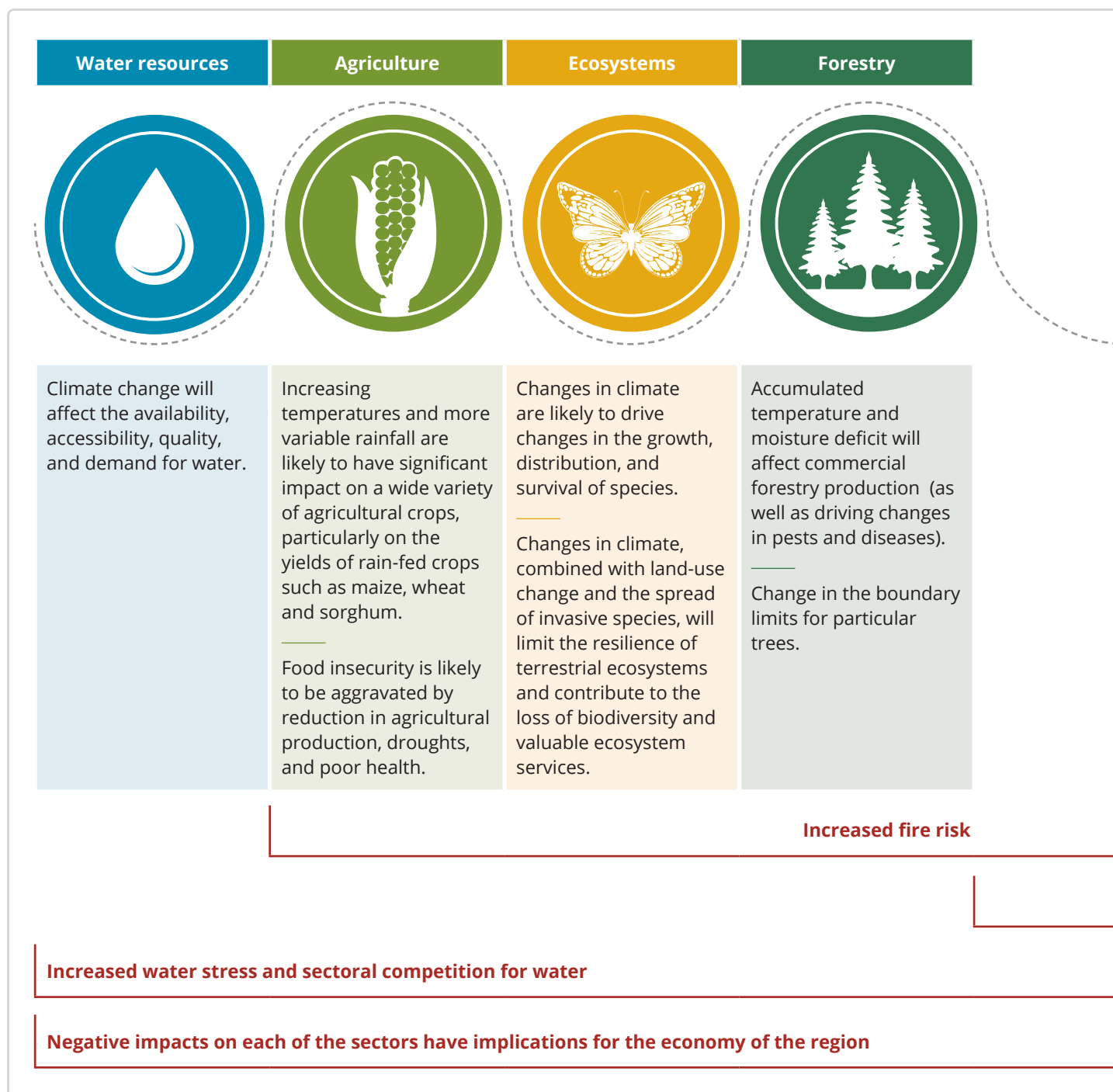
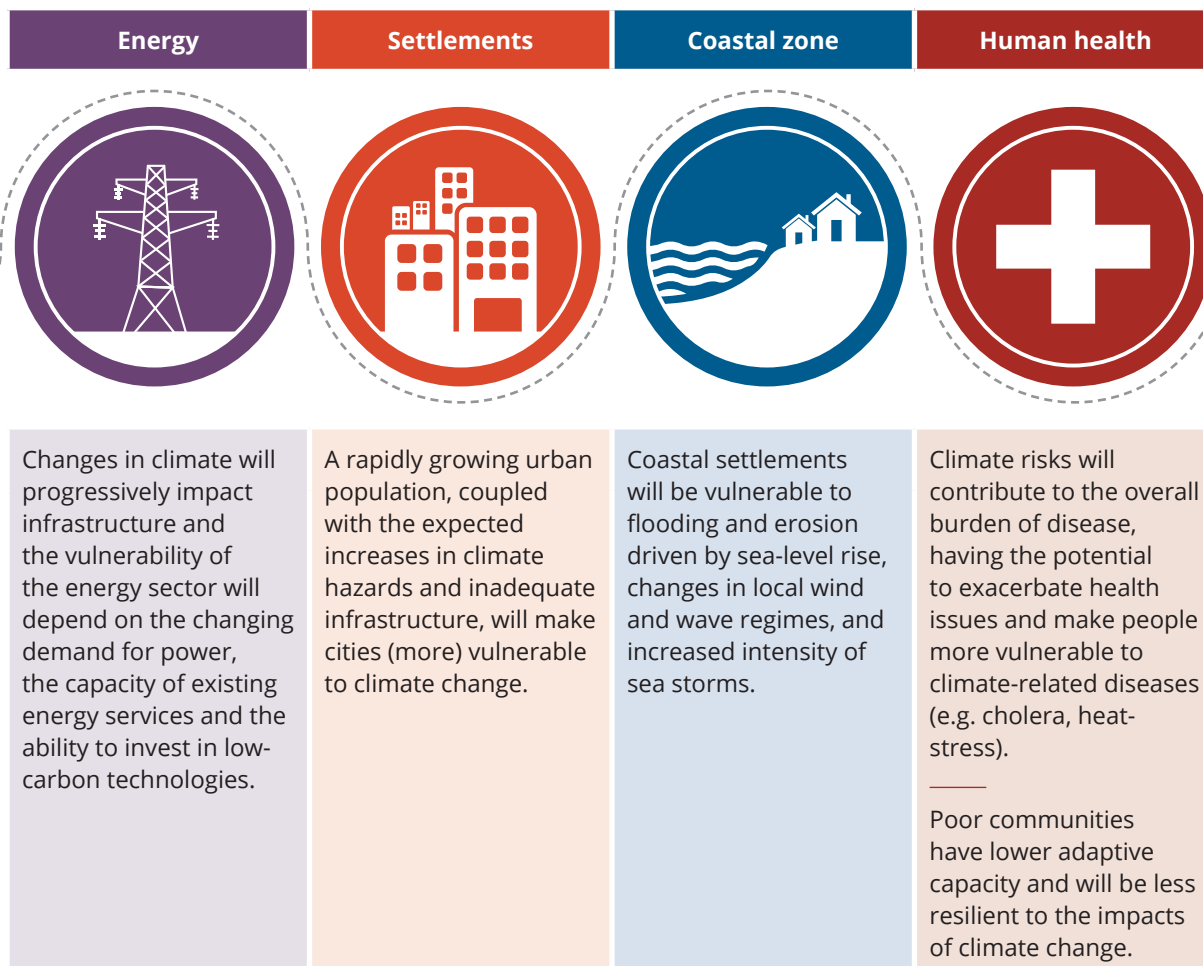


Figure 6: Cross-cutting climate risks and projected impacts to major sectors in southern Africa where negative impacts are likely to be high. Risks are considered key when there is a high probability of a hazard occurring or high vulnerability of systems exposed (or both) and for which the ability to adapt is severely constrained.





Increased risk of flooding and damage to infrastructure

Increased water stress and sectoral competition for water

Negative impacts on each of the sectors have implications for the economy of the region



5 REDUCING THE RISKS OF CLIMATE CHANGE

Following international practice, the responses to climate change can broadly be grouped into **mitigation** (reduction in the causes of climate change) and **adaptation** (reduction in the impact of climate change), which itself has significant overlaps with **disaster risk reduction**. Figure 7 outlines some examples of priority responses required to reduce vulnerability to climate change. It is important to remember that, with appropriate responses, climate change need not always be detrimental, and indeed proactive responses can exploit opportunities for climate-resilient development.



Linking adaptation and mitigation in win-win development options

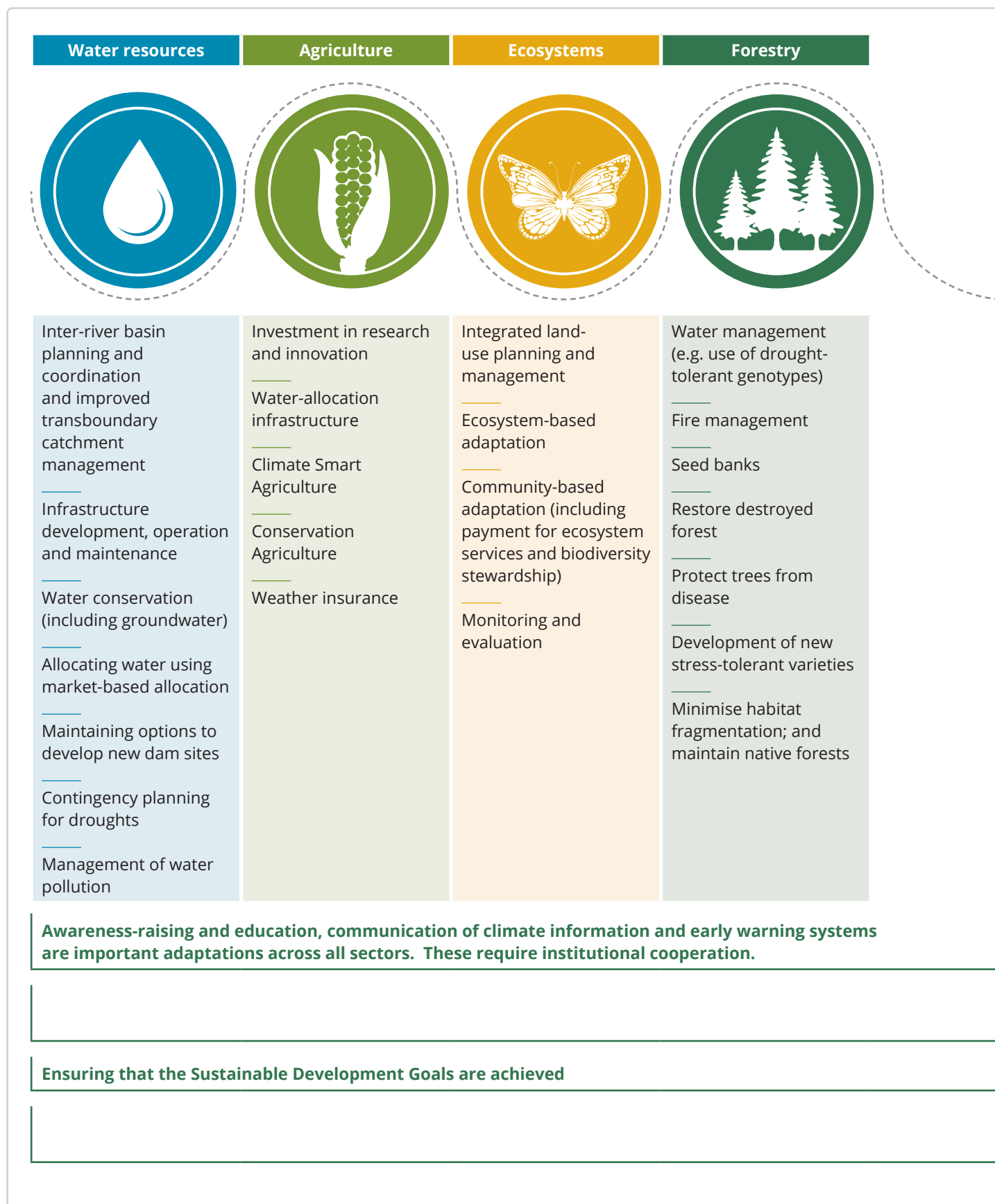
Options for development that support both mitigation and adaptation exist in agriculture, forestry, energy and infrastructure planning:




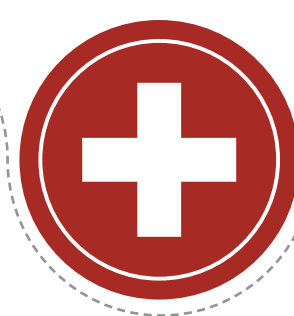
- Agriculture and forestry enable carbon sequestration (uptake of carbon in the atmosphere by the soil), whilst also contributing to land conservation, watershed management and soil moisture. Together these contribute to biodiversity conservation and ecosystem-based adaptation, which leads to greater production potential.
- Reduction in carbon emissions due to efficient burning of fuel reduces the need for deforestation which reduces vulnerability to floods. It also provides health benefits (through reducing the air pollution from burning wood and charcoal) and provides time and cost savings, particularly for women.
- Planning infrastructure can also take into account mitigation and adaptation. Buildings can be designed using features that promote adaptation, for example to enable circulation of air for cooling, and with shaded windows in the direction of the sun – whilst also being constructed with energy-efficient materials.

“Well-managed agriculture and forestry enable carbon sequestration.”



Figure 7: Summary of the potential responses to the climate risks in each of the major sectors in southern Africa



Energy	Settlements	Coastal zone	Human health
			
<p>Ensuring affordability of renewable energy (e.g. market creation, incentives for innovation)</p> <p>Policy environment to regulate energy production, transmission and consumption</p> <p>Air quality monitoring</p> <p>Policy and legislative guidelines for air quality management</p>	<p>Urban management (e.g. natural ventilation for cooling, safeguard critical infrastructure; create rainwater storage and flood retention areas)</p> <p>Land-use planning (e.g. protect high-yield agricultural land, environmentally sensitive areas and natural landscapes from urban sprawl; plan greater inter-connectivity between different land uses and transport; intensify land uses where appropriate; revise flood lines)</p> <p>Soft adaptation options, e.g. livelihood protection, social safety nets</p>	<p>Accommodate the changing sea-level by evaluating the coastal infrastructure (e.g. risk zone management, land-use planning)</p> <p>Protect with engineering (e.g. dykes, flood barriers)</p> <p>Protect with natural “soft engineering” options (drainage improvements, coastal stabilisation with vegetation, beach nourishment)</p> <p>Prevention of impacts by building new infrastructure outside of the coastal vulnerable area (land-use planning, development-free zones)</p>	<p>Cross-sectoral cooperation and collaboration</p> <p>Adaptation strategies tailored to regions or communities based upon their health risks</p> <p>Public health campaigns</p> <p>Vaccinations</p> <p>Decreasing occupational health risk to climate extremes (e.g. high temperatures)</p>

Coordination across sectors, particularly in planning and development practices that reduce vulnerability to climate hazards

Strengthening institutional capacities at local, national and regional levels for integrated resource management

6 INTEGRATING DISASTER RISK REDUCTION AND CLIMATE CHANGE ADAPTATION THROUGH RISK MANAGEMENT

Both disaster risk reduction (DRR) and climate change adaptation (CCA) are concerned with reducing vulnerability to climate hazards:

- Reducing disaster risk, which typically comes from extreme weather events, is the aim of DRR. Mechanisms focus on early warning systems – providing information and establishing an institutional infrastructure for awareness-raising and response preparedness, such that appropriate activities can be implemented in case of different alert levels.
- CCA also aims to reduce vulnerability to reduce the likelihood of harm. As well as changing the context of disasters, climate change will also manifest itself in incremental change in temperatures and rainfall. CCA thus requires a longer term and broader approach.

Some examples of activities that are considered both CCA and DRR include:

- preparing risk assessments,
- protecting ecosystems,
- improving agricultural methods,
- managing water resources,
- building settlements in safe zones,
- developing early warning systems,
- improving insurance coverage, and
- developing social safety nets.

DRR and CCA can both be incorporated in development planning through a risk management approach. This requires determining the acceptable levels of tolerance to risk and planning adaptations that are within these limits.



7 BUILDING ON GOOD PRACTICE AND EXISTING COMMITMENTS

SADC is already committed to supporting both mitigation of, and adaptation to, climate change. It has made a number of regional and international commitments for which adaptation to climate change is essential (Table 2).

SADC also has institutions in place to support DRR and CCA and complement activities in member countries. These include the DRR Unit, which undertakes annual disaster preparedness, and the Climate Services Centre, which provides seasonal forecasts and early warning through its Real Time Extreme Weather and Climate Monitoring System (MONIS).

Table 2: Regional and international commitments to support DRR and CCA

	Agreement	Selected relevant inclusions
Regional	SADC Climate Change Strategy and Action Plan (2015)	Adaptation options by sector to align with other strategies (e.g. with the Green Growth Strategy)
	SADC Regional Green Economy Strategy and Action Plan for Sustainable Development (2015)	Renewable energy and incentivising a green market
	SADC Science, Technology and Innovation Implementation Framework to Support Climate Change Response 2020	Downscaling, models, developing long-term adaptation scenarios, developing green technologies
International	United Nations Framework Convention on Climate Change – Paris Agreement	Enhancing adaptation action, including through sharing information, institutional arrangements, strengthening scientific knowledge, supporting good practice
	Sendai Framework for Disaster Risk Reduction 2015-20	Improved understanding of disaster risk in all its dimensions – exposure, vulnerability and hazard characteristics, strengthening of disaster risk governance
	Sustainable Development Goals	Goal 13 to “take urgent action to combat climate change and its impacts”, including strengthening resilience and adaptive capacity, improving education, awareness-raising and human and institutional capacity

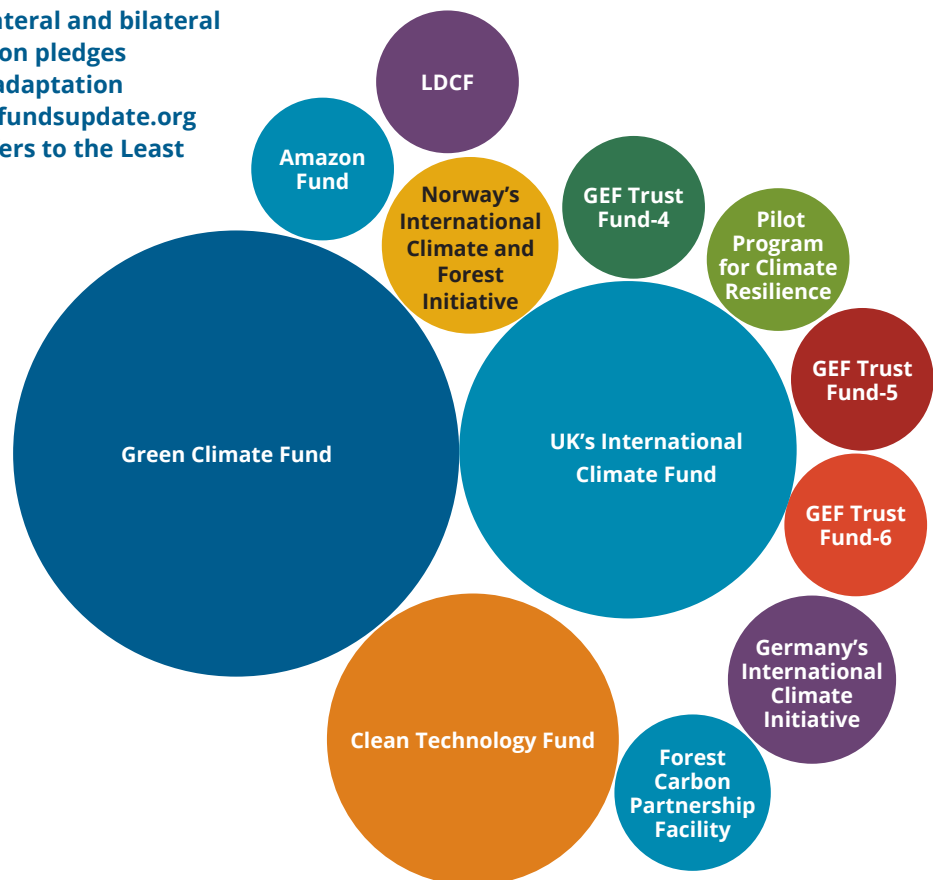
8 FINANCING THE COSTS OF ADAPTATION

Although the costs of adaptation are large, climate finance is available, for example through the recently introduced Green Climate Fund (Figure 8). Malawi is the first of the SADC countries to successfully apply to the Green Climate Fund for US\$12.3 million to scale up the use of modernised climate information and early warning systems.

From over 60 international climate finance sources, some of the key ones are:

- Funds under the United Nations Framework Convention on Climate Change, including the Green Climate Fund, Adaptation Fund, Special Climate Change Fund and Least Developed Countries Fund
- Other Multilateral Funds, such as the Climate Investment Funds and the Global Environment Facility Trust Fund
- ClimDev Special Fund and the African Climate Change Fund (African Development Bank) and the Climate Change Fund (New Economic Partnership for Africa's Development (NEPAD) and the African Climate Change Fund (African Development Bank)
- Dedicated bilateral climate funds – typically linked to existing development cooperation and aid flows

Figure 8: Size of various multilateral and bilateral climate finance sources based on pledges (includes both mitigation and adaptation sources). Source: www.climatefundsupdate.org (data from May 2016). LDCF refers to the Least Developed Countries Fund.



ABOUT THE CLIMATE RISK AND VULNERABILITY HANDBOOK FOR SOUTHERN AFRICA (2ND EDITION)

The 2nd edition of the Risk and Vulnerability Handbook for Southern Africa presents the latest information on what climate change means for southern Africa and provides key messages that can be used in decision-making. The handbook is divided into three parts: (i) Understanding the climate risks to southern Africa, (ii) understanding the vulnerability of southern Africa to climate change, and (iii) responding to climate change.

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ENDNOTES

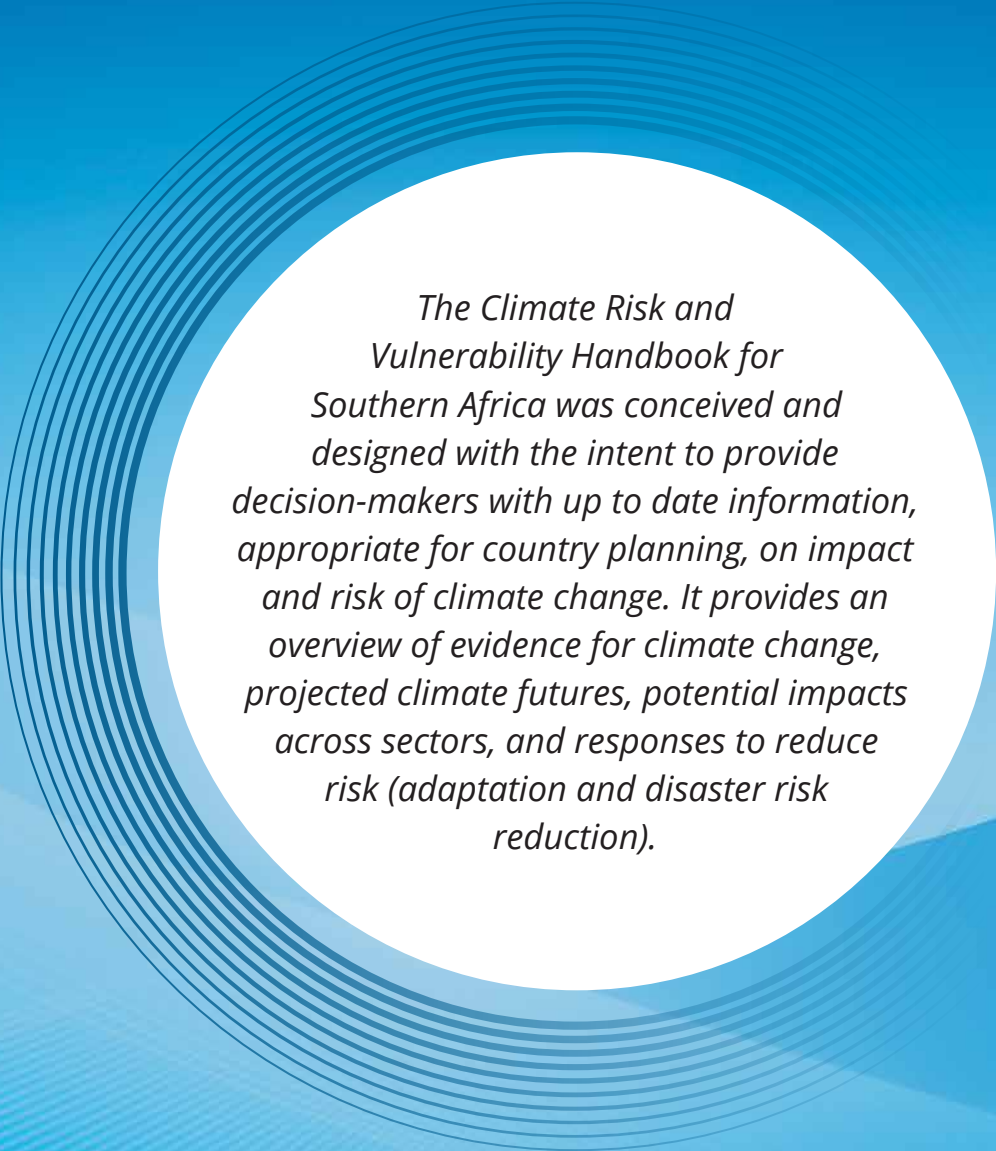
- i CRUTEM4 (Climatic Research Unit Temperature, version 4) land-surface temperature data set.
- ii CRU TS 3.23 (Climatic Research Unit time series version 3) dataset for the period 1900 to 2014.
- iii Based on the latest dynamically downscaled projections from the CSIR (NRE) using the conformal-cubic atmospheric model (CCAM).
- iv 'Wildfires' refer to any uncontrolled and non-prescribed burning of plants in a natural setting; 'storms' to tropical, extra-tropical and convective storm events; 'floods' to riverine, flash and coastal flood events; 'extreme temperature' to both cold waves and heat waves; and 'droughts' to extended periods of unusually low precipitation that produce a shortage of water.
- v 'Climatological' refers to droughts and wildfires, 'hydrological' to floods and landslides, and 'meteorological' to extreme temperatures and storms.
- vi Based on data from the Centre for Research on the Epidemiology of Disasters (CRED)/Emergency Events Database (EM-DAT) (www.emdat.be).
- vii Rogers, D. & Tsirkunov, V. 2011, "Costs and benefits of early warning systems", Global Assessment Report on Disaster Risk Reduction.
- viii CSIR 2015, 17 November 2015 – last update, Media statement issued at the El Niño Summit hosted by the South African Weather Service, ACCESS, CSIR, University of Cape Town, University of Pretoria and Wits University. Available: http://ntww1.csir.co.za/plsql/ptl0002/PTL0002_PGE157_MEDIA_REL?MEDIA_RELEASE_NO=7527029 [2016, 6/19/2016].
- ix Cai, W., McPhaden, M.J., England, M.H., Wang, G., Guilyardi, E., Jin, F-F., Collins, M. and Wu, L., 2014, "Increasing frequency of extreme El Niño events due to greenhouse warming", *Nature Climate Change*, 4, 111-116.
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The Climate Risk and Vulnerability Handbook for Southern Africa was conceived and designed with the intent to provide decision-makers with up to date information, appropriate for country planning, on impact and risk of climate change. It provides an overview of evidence for climate change, projected climate futures, potential impacts across sectors, and responses to reduce risk (adaptation and disaster risk reduction).

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