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AFRICA'S CLIMATE HELPING DECISION-MAKERS MAKE SENSE OF CLIMATE INFORMATION





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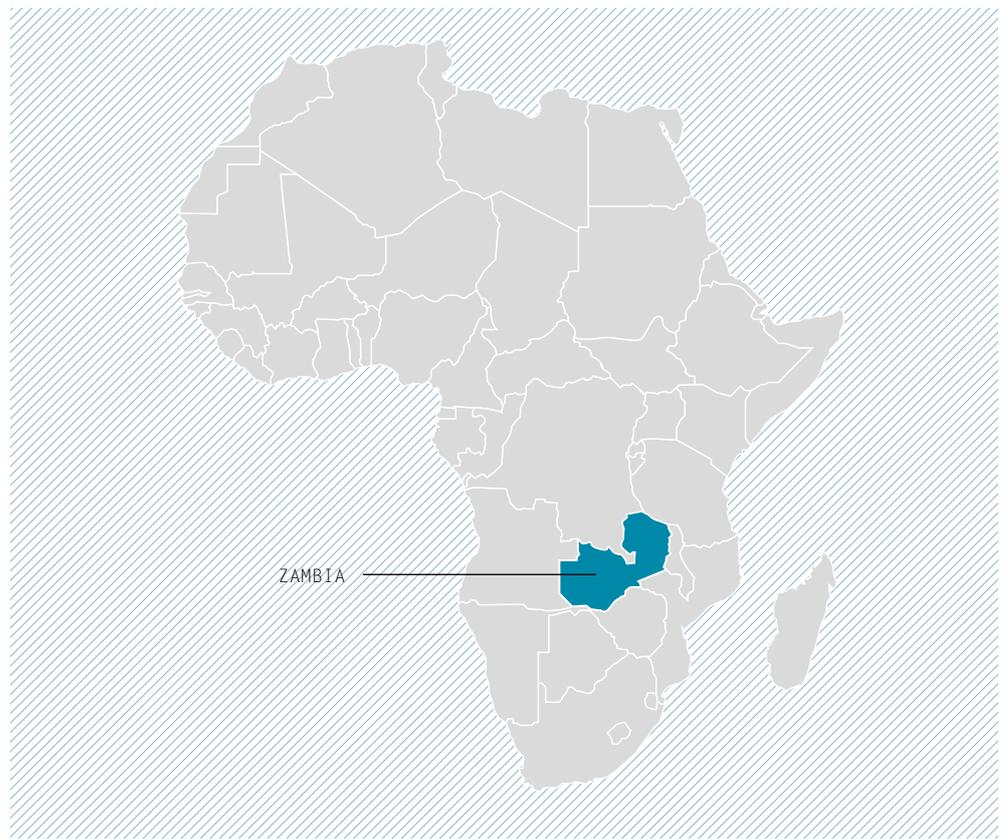
GENERAL READERS

ZAMBIA
COUNTRY
FACTSHEET

KNOWING THE CLIMATE, MODELLING THE FUTURE

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NEED TO KNOW

Climate change will impact significantly on Zambia's water supplies, which will cascade through the energy and agricultural sectors, and impact the entire economy. Climate scientists hope to provide Zambian decision-makers with information that can help them plan appropriately for this uncertain future. This research considers:

- how sensitive Zambia's water system is to disruption by rising temperatures and changing rainfall patterns
- how the climate system across the region works
- the strengths and weaknesses of the current climate models, in terms of projecting future changes to the system.

OVERVIEW

Zambia is critically dependent on water and sound water management practices

Zambia is a country of rivers, wetlands, rich wildlife, and mineral reserves. The map below illustrates how the country is dominated by the Zambezi River and its catchments. Almost 100% of its electricity is produced by hydroelectric sources¹, most notably the Kariba hydroelectric scheme. Similarly, local food production is dependent on the river for irrigation. Zambia is critically dependent on water and sound water management practices.

WATER: KEY TO THE ECONOMY

One of the most pressing climate-related issues for Zambia is water supply to the nation's capital city, Lusaka. Lusaka currently sources around 50% of its water through pumps and a pipeline from the Kafue River, 60km south of the city. The remaining 50% is sourced from an array of around 90 well points across the broader city. Both the Kafue pipeline pumps and the borehole pumps require large amounts of electrical power to operate. As a result there is a strong relationship between power supply stability and water supply for the city.

The recent drought conditions combined with other factors have resulted in the Kariba hydropower scheme's reducing its output significantly, with subsequent regular power cuts across Zambia, including Lusaka. This has, in turn, limited pumping capacity, resulting in water shortages across the city.

While the current drought will pass, growing urban population and water demand will increasingly stress existing water supply capacity, even without amplification of these stresses due to climate change. Current plans and infrastructure development are focused largely on upgrading the Kafue-Lusaka water supply through new pipelines and upgraded pumping. However, these plans may need to be influenced by constraints imposed by future needs of multiple water users including farming, energy generation, and environment.

Expanding the groundwater well-fields remains another option if water quality concerns resulting from industrial contamination of the groundwater can be managed. In fact, recent shortages in municipal water supply have already caused expansion of the system of private boreholes tapping groundwater under the city. As it is largely uncontrolled, it creates the

¹ www.iea.org/countries/non-membercountries/zambia

potential for resource over-exploitation, pollution, and problems of a social nature related to equity of access.

However, regardless of water sources, energy supply to support pumping and treatment is a key issue. This expands our focus beyond Lusaka and the Kafue to the Kariba Dam, but also to the region as a whole and the southern African Power Pool (SAPP). Will the Grand Inga project in the Congo significantly alter the regional power landscape? How will climate impact on other regional power supplies such as ESKOM in South Africa, and Cahora Bassa in Mozambique?

CLIMATE DATA OVERVIEW

The Zambian Meteorological Department (ZMD) is the primary weather observing institution in Zambia. ZMD manages a network of 37 weather stations across the country, which is supplemented by other networks operated by institutions such as the Zambian Electricity Supply Corporation (ZESCO), and new initiatives such as the southern African Science Service Centre for Climate Change and Adaptive Land Use (SASSCAL). Some of this data is available to researchers through global station data archives such as the Global Historical Climatology Network. However, for many stations, publicly available records end in the late 1990s or early 2000s, which limits analysis of recent variability and trends. Figure 2 below shows the number of observing stations contributing to one of the blended satellite-station rainfall datasets for Zambia, and shows a rapid decline over the past 40 years. Considering the fairly wide ranging climate across Zambia, a sample of less than 20 stations is far from adequate to accurately describe its climate.

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The ZMD does continue to archive more complete data, and these data can be made available as a service offered by ZMD.

As a result of the lack of primary observed data for Zambia, much of the work on historical climate trends and variability analysis is dependent on merged satellite and re-analysis data products (please see *Southern Africa: tools for observing and modelling climate* fact sheet). The analyses of these datasets indicate the lack of strong rainfall trends, but increases in air temperature. These are set against a relatively high level of natural variability at inter-annual to multi-decadal time scales.

CLIMATE PROCESSES

Most of Zambia receives rain during November to April. The highest summer rainfall occurs in the north-east parts of the country, and gradually decreases towards the south-west. This pattern is determined by the seasonal migration of the boundaries between three distinct air streams that form within the tropical and sub-tropical circulation systems:

- the north-easterly monsoon bringing in warm and moist air from the tropical western Indian Ocean,
- the south Indian Ocean anticyclone creating a flux of cooler and less saturated air from the mid-latitude Indian Ocean,
- the inflow of cooler and less moist air from south Atlantic redirected within the equatorial westerlies.

In this complex system, rainfall over Zambia is influenced by how far southwards the air masses meet (or converge), and how much moisture is brought in from over the oceans.

These, in turn, depend on the sea surface temperatures, and the configuration of high pressure systems over the oceans to the east and west of the subcontinent. They are also affected by global drivers of climate variability, such as El Niño Southern Oscillation (ENSO), and by human-caused climate change.

CLIMATE PROJECTIONS

There are two sources of climate projections for Zambia. A set of Global Climate Models (GCM), available through the CMIP5 archive, gives projections that the United Nations Intergovernmental Panel on Climate Change (IPCC) includes in its Fifth Assessment Report (AR5). The other key source is a series of 'downscaled' climate projections, which zoom in more closely on the region. The CMIP5 projections, simulations of future climate from 17 centres throughout the world, differ from each other for a number of reasons, expressing an aspect of uncertainty in projecting future climate. It is impossible to select a single 'best' model or simulation, and the ensemble simulations have to be looked at concurrently, considering the spread of the results as an expression of this uncertainty in projections and variability in climate.

Figure 3, from the IPCC AR5, gives information at a broad spatial scale. It shows that overall, the GCMs project mostly no change to drying across the broader Zambian region for the wet season (October to March). However, it is only the drier subset of models (left column) which show drying that is more than naturally observed in the past. The middle and 'wetter' subset of models (middle and right column) show almost no real change, and no changes greater than natural observed variability.

Figures such as those in Figure 4 are traditionally used to present climate projections, but do not easily convey the distinction between the robust and the uncertain aspects of these projections. Scientists are thus developing alternative approaches that provide a better overview of future conditions. For example, Figure 4 illustrates rainfall projections for the region of Lusaka from a number of models, where the projected rainfall is tracked through time, and the strong departures from the natural (recent) levels are highlighted. The majority of projections stay within conditions similar to these observed in the past, and only a few indicate consistently drier conditions, with rainfall reduced by 15% to 20%.

Figure 5 shows how air temperatures for Lusaka might change over time. Here we can see that temperatures are consistently projected to rise in the future, strongly exceeding the levels of natural variability, and, towards the end of 21st century, reaching 1.8°C to 3.2°C above the recent levels.

GCM projections, as presented above, provide a broad overview of future climate, and do not allow for differentiating various local influences that may be relevant from water resources and development planning perspective. Such information can be obtained from downscaled projections, however.

Dynamically downscaled projections are being generated through the Coordinated Regional Climate Downscaling Experiment (CORDEX). Unfortunately, at this stage, few simulations are available, which do not allow for scientists to paint a defensible picture about the future climate emerging from this set of models. The results, however, concur broadly with the GCM-based projections for the region. The work continues, and it is expected that in near future, CORDEX data will lead to an improvement of our understanding of future climate in southern Africa and in Zambia.

Statistically downscaled projections are available through the University of Cape Town (UCT) Climate Information Platform (CIP: <http://cip.csag.uct.ac.za>). The plots in Figure 6 and Figure 7 below show statistically downscaled projected changes per month for the 2040 to 2060 period for Lusaka. These results paint a similar picture to that created by GCM projections, in terms of rainfall totals, i.e. that some drying or no change in the future is expected. However, they also indicate that these rainfall totals will be delivered in less frequent events resulting in longer dry spells, mostly during the already dry season but also extending into the early and late rainfall season.

ZAMBIA'S FUTURE CLIMATE

It is clear from all the various projections that temperature increases are expected. These will have significant impacts on a wide range of sectors

It is clear from all the various projections that temperature increases are expected. These will have significant impacts on a wide range of sectors including the water sector, where increased evaporation is likely to reduce runoff and infiltration, increase losses from dams and wetlands, and increase water demand for irrigation and domestic uses.

As a consequence, the moderate uncertainty around projected changes in rainfall is less important. Regardless of changes in rainfall, there will be consequences for water resources across the country.

FCFA'S FRACTAL PROJECT

Project objectives

One of the chief scientific challenges for understanding southern Africa's climate is that different models give contradictory scenarios for climate trends in the next five to 40 years. FRACTAL's team will advance scientific knowledge about regional climate responses to human activities and work with decision-makers to integrate this scientific knowledge into climate-sensitive decisions at the city-regional scale (particularly decisions relating to water, energy and food with a lifetime of five to 40 years).

The institutions involved in FRACTAL are:

- University of Cape Town
- Met Office (UK)
- Stockholm Environment Institute
- START
- ICLEI–Local Governments for Sustainability
- Swedish Meteorological and Hydrological Institute/ Sveriges Meteorologiska och Hydrologiska Institut
- Red Cross Red Crescent Climate Centre
- University of Oxford
- Aurecon
- Council for Scientific and Industrial Research
- US National Atmospheric and Space Administration
- Lawrence Berkeley National Laboratory
- European Commission Joint Research Centre
- City of Cape Town
- City of eThekweni

FIGURES

Figure 1²

Zambia's water resources are key to its economy and food security. This map also shows the country's climate observation network.

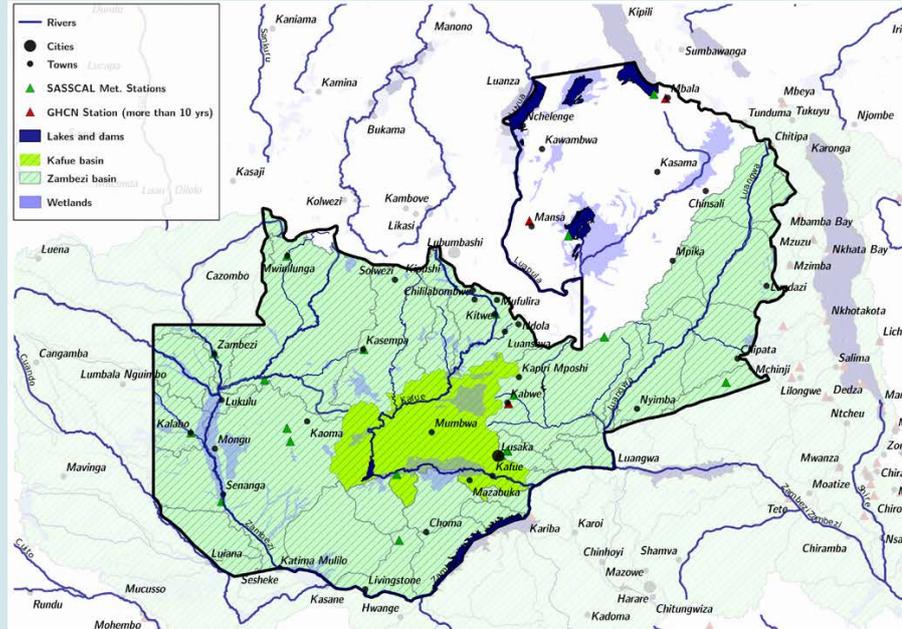


Figure 2³

Number of rainfall stations from Zambia, contributing in the last 35 years to global data archives used in derivation of blended satellite-station rainfall datasets.



- 2 Generated by the authors.
- 3 Generated by the authors.

Figure 3⁴

Projections of future rainfall for Africa under RCP4.5⁵ emission scenarios.

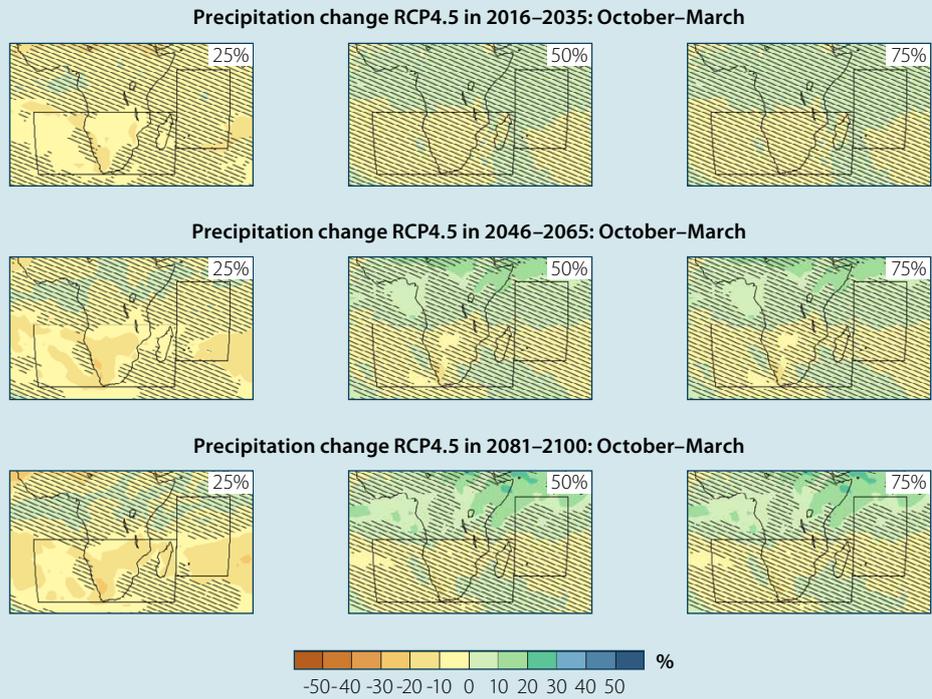
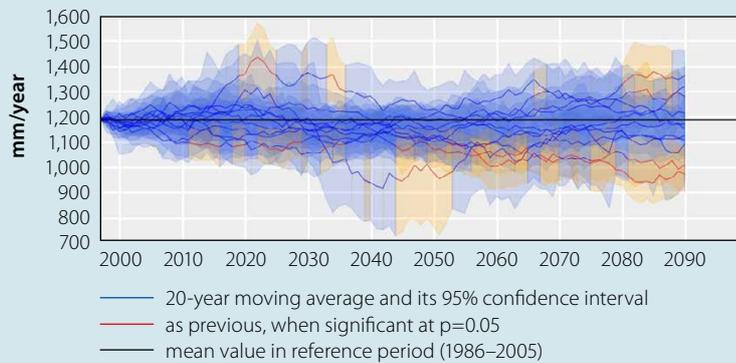


Figure 4⁶

Trajectories of total annual rainfall over Lusaka, simulated and projected by an ensemble of GCMs under RCP4.5 emission scenario.



4 IPCC, 2013: Annex I: Atlas of Global and Regional Climate Projections [van Oldenborgh, G. J., M. Collins, J. Arblaster, J. H. Christensen, J. Marotzke, S. B. Power, M. Rummukainen and T. Zhou (eds.)]. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T. F., D. Qin, G. -K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P. M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

5 Climate projections are conditional on the future level of emissions of greenhouse gases. These are reflected by a number of emission scenarios. Scenario coded RCP4.5 considers a moderate reduction of emissions in the future compared to current levels, and is perhaps a realistic mid-way between 'business as usual', and the commitments arising from the 2015 Paris Agreement achieved at the UN Conference of the Parties, COP21.

6 Generated by the authors.

Figure 5⁷

Trajectories of mean annual air temperature over Lusaka, simulated and projected by an ensemble of GCMs under RCP4.5 emission scenario. Legend as in Figure 4.

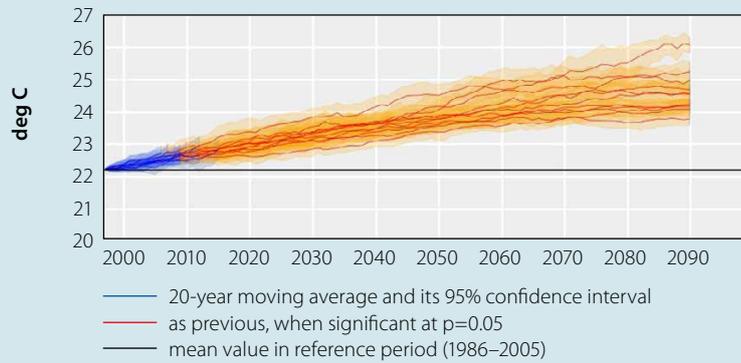


Figure 6⁸

Downscaled projections of total monthly rainfall for Lusaka.

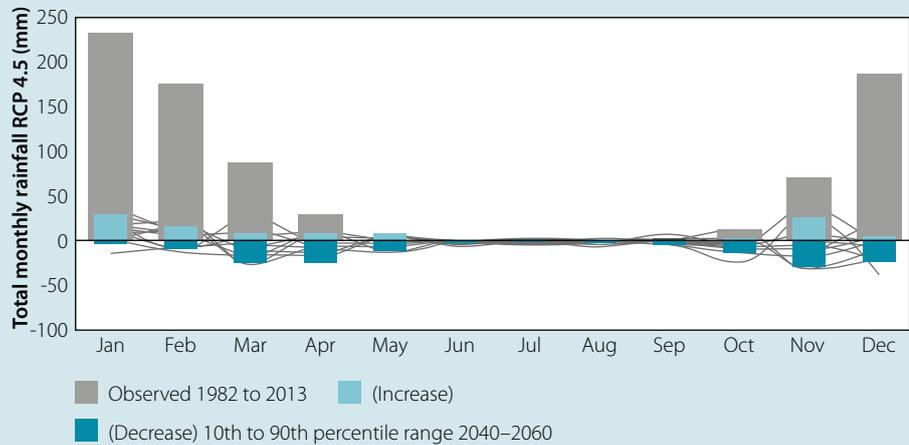
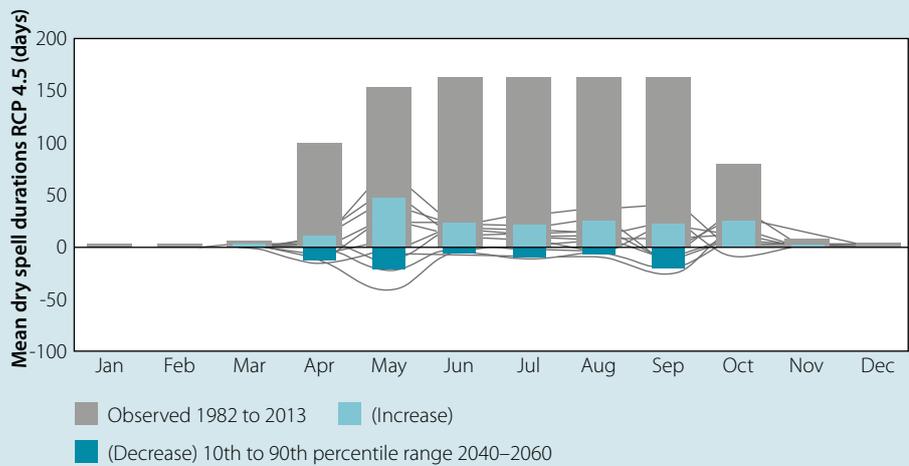


Figure 7⁹

Downscaled projections of dry spell duration for Lusaka.



7 Generated by the authors.

8 Climate information Platform, <http://cip.csag.uct.ac.za/webclient2/app/>

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