The Fourth South African Climate Change Tracking Report

forestry, fisheries & the environment

Department:
Forestry, Fisheries and the Environment
REPUBLIC OF SOUTH AFRICA

2030 NDP

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FOREWORD

The objective of the fourth South African Climate Change Tracking Report is to communicate the progress and lessons learnt in tracking South Africa's Transition towards a climate resilience society and a lower carbon economy. The report details a suite of climate change related indicators that are tracked overtime to inform South Africa's domestic audience about climate related observations, the risks and vulnerabilities to climate change as well as climate responses relating to adaptation, mitigation and finance.

The indicators are based on system narratives aligned to the National Determined Contribution (NDC) and Sustainable Development Goals (SDGs) in the six thematic developmental areas, which include:

- Narrative0: Climate Realities,
- Narrative : Economic Structure, Work Creation and Economic Growth,
- Narrative 2: The Energy Transition,
- Narrative 3: Water for Development,
- Narrative 4: Social Vulnerability,
- Narrative 5: Sustainable Urban Centres,
- Narrative 6: Sustainable Rural and Semi-Rural Landscapes.

The Annual Climate Change Tracking Report indicators reflect the complex dynamics of the South African socio-economic context or system and provide progress tracking on economic, climate and environmental linkages nexus. These set of indicators have been developed and grouped under each narrative description, focusing on diagnosing the evolving state of each sub-system and exposing the inter-linkages between systems—in particular between the economic, social and environmental systems— and the intersection between these and climate change.

The resultant indicators are intended to track and communicate the causes and effects of climate change. The indicators are aligned with the South African National Determined Contribution (NDC) and Sustainable Development Goals (SDGs), The target audience for this report includes policy and decision makers, practitioners; communities, research institutions, private sector entities and finance institutions.

I wish to thank all collaborating institutions and individual experts who shared data and contributed in the compilation of this report. Going forward, and to sustain periodic updates and reporting, DFFE will be closely collaborating with institutions affected by the indicators for data collection and updates.

I am pleased to present the fourth South African Climate Change Tracking Report to our local audience as part of our departmental mandate to report progress achieved in our endeavour to transition South Africa to lower carbon economy and climate resilient aspirations.

Ms. Barbara Creecy
Minister of Forestry, Fisheries and the Environment (DFFE)

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ACKNOWLEDGEMENTS

Department of Forestry, Fisheries and the Environment (DFFE) wishes to acknowledge the sterling support and contribution made by collaborating partners and individuals in the development of South Africa's Fourth Climate Change Tracking Report.

This report was funded through the GIZ implemented Climate Support Programme which is part of the International Climate Initiative (IKI).

The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) supports the IKI on the basis of a decision adopted by the German Bundestag.

The Department wishes to further acknowledge the excellent technical contribution made by the University of Cape Town working with the number of technical experts who served as resource persons for this report. The report has also been enabled by contributions of individual experts from DFFE in their various Directorates within the department. This annual report presents an improvement over the previous ones as it is the first indicator based Climate Change Tracking Report which will be institutionalized and build upon going forward.

INTRODUCTION

South Africa is undertaking a variety of actions to respond to the causes and effects of climate change. South Africa's responses, through adaptation and mitigation actions, is guided by the National Climate Reponse Policy (2011) and the National Climate Change Adaptation Strategy, and with international commitments as stipulated in the updated Nationally Determined Contributions (NDC). Aspects of this are in the process of being made legally binding through the National Climate Change Bill. The Bill has already been promulgated what is still to be inacted is the Climate Change Act.

Tracking and communicating the progress on these actions is important for keeping activities on course, and for ensuring widespread buy-in and accountability as well South Africa's transparency of action. The National Climate Change Report is an opportunity to report and reflect on this progress. The Report provides periodic domestic reporting on climate change response action in South Africa. To this end, indicators, observations or calculations that track conditions or trends, are one way to ensure rigorous tracking of progress in a consistent manner.

This is the first National Climate Change Report in which indicators are presented, reported and reflected upon, a step forward for the South African Climate Change Monitoring and Evaluation System. The aim is for future National Climate Change Reports to iterate this effort with a substantiated and reviewed set of indicators.

In developing and engaging with stakeholders on the initial set of indicators it is apparent that the indicators must reflect the complex dynamics of the South African socio-economic context or system, and how this system intersects with climate and environmental change. This has underpinned the development of indicators to allow them to contribute to ongoing interventions.

Therefore, the approach taken in the Fourth South African Tracking Report aims to capture the complex dynamics of the South African socio-economic system through a set of system narratives. A set of indicators have been developed and grouped under each narrative description, focusing on diagnosing the evolving state of each sub-system and exposing the interlinkages between systems – in particular between the economic, social and environmental systems – and the intersection between these and climate change.

The intention is for the indicators to encourage and support the interrogation and exploration of the deep systemic issues posing challenges to South Africa's response to climate change, rather than merely tracking the climate change implications and surface responses.

APPROACH

Consideration needs to be made to come up with smart indicators to be tracked overtime to inform policy and decision making. The development of relevant and strategic climate indicators requires taking a step back from the siloed approach to 'to focus on the system approach that integrates environmental, social and economic dimensions. The environment is intricately entwined within the wider societal and economic systems which cannot and should not be treated as separate entities. In recognising this complex interconnectedness, the approach to developing indicators to track South Africa's progress on the national response to climate change takes a systemic approach. This holds the promise of capturing much of the systemic impact of climate change and of response measures. Boulanger (2008) provides a good synthesis of different approaches to developing sustainable development indicators, all of which can be traced back to the pioneering work of Lazarsfeld in the 1960s. These approaches are based on moving from a conceptual phase, which in the case of sustainable development is almost without exception based on a systems approach, through key attributes to indicators (Boulanger, 2008). The most common approach involves a combination of the economic, social and environmental aspects of sustainable development. For this approach it is necessary to overlay these three systems with a 'climate lens', detailing the relationship between climate change and the respective components of the three systems.

While a systemic perspective is necessary to gain a deep insight into climate change and climate change impacts, and important for mobilising strategic responses to climate change, it is equally important to recognise that no one sees, governs and understands the whole system and that individual perceptions of the system are always subjective (Daron *et al.*, 2014; Eyre *et al.*, 2017). Any of the systems important for understanding climate change could be described in several different ways (depending on who is in the room, or what literature is drawn on). The key challenge, outlined in a section titled "The difficulty: so many systems and variables to watch" in Bossel (1999), is to limit the description of the system, including the climate lens and the resulting indicators, to a usable number of essential relationships or threads. This challenge was embraced and the conceptual notion of threads (or narratives as they are called here) underlay the methodological development of the approach to represent the complexity of the South African system, ultimately resulting in the basis for identifying indicators.

There is no single way to analyse or describe a complex system in narrative form, thus an iterative process of investigation into an approach that is appropriate for representing the South African system was employed. This consisted of literature review; testing for policy relevance; expert and stakeholder elicitation; and testing for linkages and compatibility with existing indicator sets and applications (for instance the Sustainable Development Goal (SDG) indicators, and indicators relevant to South Africa's NDC).

The interim result of this process was a deconstruction of the elements and attributes that define each systemic pillar of the economy, society and environment within a South African context. A small number of elements were selected for each 'pillar' and key attributes were identified for association with each element. This provided the framework for mapping each element and attribute into a system of interactions that drew linkages across each of the pillars. It had particular value in foregrounding the complex system that emerges.

Based on this mapping exercise, a set of narrative descriptions were developed that expose the predominant interlinkages within the South African system – in particular between the economic, social and environmental systems – and the intersection between these and climate change. These narratives have been developed in line with the national priorities contained in the National Development Plan, national departmental strategies and current literature.

The system narratives are:

- **Narrative 0:** Climate Realities
- **Narrative 1:** Economic Structure, Work Creation and Economic Growth
- **Narrative 2:** The Energy Transition
- **Narrative 3:** Water for Development
- **Narrative 4:** Social Vulnerability
- **Narrative 5:** Sustainable Urban Centres
- **Narrative 6:** Sustainable Rural and Semi-rural Landscapes.

Within the framework of each narrative, a final step was taken to draw out indicators that represent each narrative thread. Some of these are composite – speaking to multiple nodes in a thread or nodal intersection in the system – and some speak to singular nodes that make up the thread. All the indicators identified in this document should be considered together with the climate realities represented in Narrative 0.

References

Bossel, H., 1999. Indicators for sustainable development: theory, method, applications (p.138). Winnipeg: International Institute for Sustainable Development. Canada. Boulanger, P.M., 2008. Sustainable development indicators: a scientific challenge, a democratic issue. SAPI EN. S. Surveys and Perspectives Integrating Environment and Society, (1.1).

Daron, J.D. and Colenbrander, D.R., 2015. A critical investigation of evaluation matrices to inform coastal adaptation and planning decisions at the local scale. Journal of environmental planning and management, 58(12), pp.2250-2270.

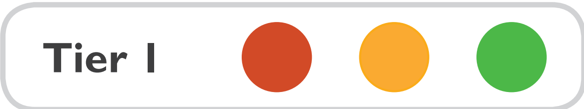
Eyre, N., Darby, S.J., Grünewald, P., McKenna, E. and Ford, R., 2018. Reaching a 1.5°C target: socio-technical challenges for a rapid transition to low-carbon electricity systems. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 376(2119), p.20160462.

HOW TO USE THIS DOCUMENT

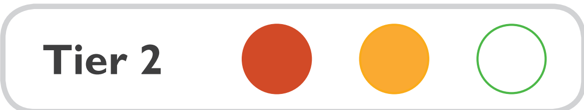
The following tier groups have been applied in the report to guide users on the level of each indicator applicability.

Indicator tiers

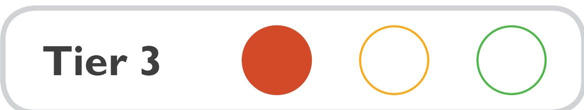
Tier allocations, in the final section of each indicator, mean:



The indicator is conceptually clear with established methodology and data is easily available. It has been graphed and completed.



The indicator is conceptually clear and methodology exists, however, there is a lack of clarity on whether data exists or once-off or partial data may exist, but is not currently being captured systematically. It has been reported on, however, with incomplete or sub-ideal data.



The indicator is still being conceptualised, and a variety of methodologies and data are being considered. It has been presented as a case study, and for full reporting in future reports.

Key to icons

This indicator is a case study. It is based on a paper or study for which the data sample is not nationally representative (Tier 3)

This indicator cannot be reported here, and needs work in future iterations (Tier 4)

THEMATIC AREA

NARRATIVE 0

CLIMATE REALITIES

Contents

Figures and Tables

INTRODUCTION TO THE CLIMATE REALITIES NARRATIVE

The evidence for global climate change is now overwhelming. Global average air temperatures are nearing 1˚C warmer than pre-industrial (1850-1900) average temperatures (NOAA, 2019) and it is possible to robustly attribute increasing frequencies and intensities of extreme events, drought, heat waves, and flooding, to anthropogenic drivers (caused by human activities) and global climate change. Ocean temperatures and sea levels are also rising along with ocean acidity resulting in a range of observed impacts including coastal erosion, ocean ecosystem shifts, and species depletion. Shifts in wind regimes further impact ocean dynamics and environments including fish populations. Projections point towards continued warming of the atmosphere and oceans and continued changes in climate extremes (IPCC SREX). While emissions reductions through mitigation and associated sector transitions have the potential to limit future changes and impacts to some extent, further changes are unavoidable (IPCC SR15).

Globally, the negative impacts of climate change are increasingly being identified, understood and quantified (IPCC SR15). These negative impacts are wide ranging from ecosystem degradation and species loss, damage to infrastructure and loss of lives and livelihoods through extreme events, food security crises and extensive human health impacts both directly and indirectly.

Additionally, international negotiations and agreements to reduce emissions of greenhouse gases (GHGs) through national commitments to mitigation place increasing pressure on governments to implement aggressive energy and economic transitions through shifts in policy and associated legislation. For developing countries like South Africa, navigating these complex transitions while simultaneously ensuring ongoing economic growth and poverty reduction is extremely challenging.

In the South African context, climate variability has long played a significant role through droughts impacting agriculture as well as the impact of extreme events, mostly flooding, on vulnerable and exposed communities. While rapid urbanisation and associated informal housing and lack of infrastructure, as well as rural land degradation, contribute to increasing impacts from climate variability, evidence is mounting that climate change is further enhancing the frequency and magnitude of climate impacts through more frequent extremes (e.g. droughts) (Otto, 2018), higher temperatures, and in some cases, more intense rainfall events. However regional climate variability and change is complex, and, in many cases, trends indicate decreasing frequency of rainfall extremes. While South Africa's coast is not as vulnerable to sea-level rise as some countries, local exposure, particularly in high-value residential and commercial areas, is considerable. South Africa's blue economy is significant in some provinces and the impact of shifting wind regimes and warming oceans is beginning to emerge, though it is challenging to attribute this definitively to climate change. However, projected changes point towards a continuation and possibly even an acceleration of both ocean and atmospheric changes and these shifts require rapid and proactive responses in the form of adaptation as well as ongoing strategic development (e.g. formal housing and infrastructure).

Ongoing monitoring of global, but more critically local, climate indices contributes to the growing understanding of climate variability and change as a societal stressor. This requires robust and open data collection, sharing and analysis supported by strong institutional capacity and inter-institutional agreements. Climate variability and extremes often have multifaceted interactions with negative impacts, particularly in complex socio-economic contexts where impacts can propagate across sectors, across space and through time (as delayed shocks). Foundational research, supported by ongoing and rapidly updated observations of climate and non-climate data, is required to inform policy, planning and other interventions.

0.1 INDICATOR 0.1: ANNUAL MEAN AND EXTREME TEMPERATURES

Indicator definition

Annual average temperature relative to historical averages and count of hot days (days hotter than the hottest 5% historically) relative to historical averages, aggregated to provincial and national level.

Indicator rationale

Long-term climate change due to the activities of humans has primarily been evidenced by increasing global air temperatures since the early 20th Century (IPCC). Air temperature is therefore an important indicator of global change both globally and regionally. Regional dynamics and local features influence the rate of warming spatially with some regions (e.g. the Arctic) warming more rapidly than the global mean rate of warming. Likewise, across South Africa different regions are warming at different rates with the western interior warming most rapidly and coastal areas less rapidly.

Temperature increases, including the resultant increase in frequency of extremes (hot days and heat spells) are primary drivers of climate variability and change impacting directly through heat stress on people, livestock, crops and vegetation, and indirectly through the evaporation of soil and open water impacting moisture budgets and water availability.

Data visualisation

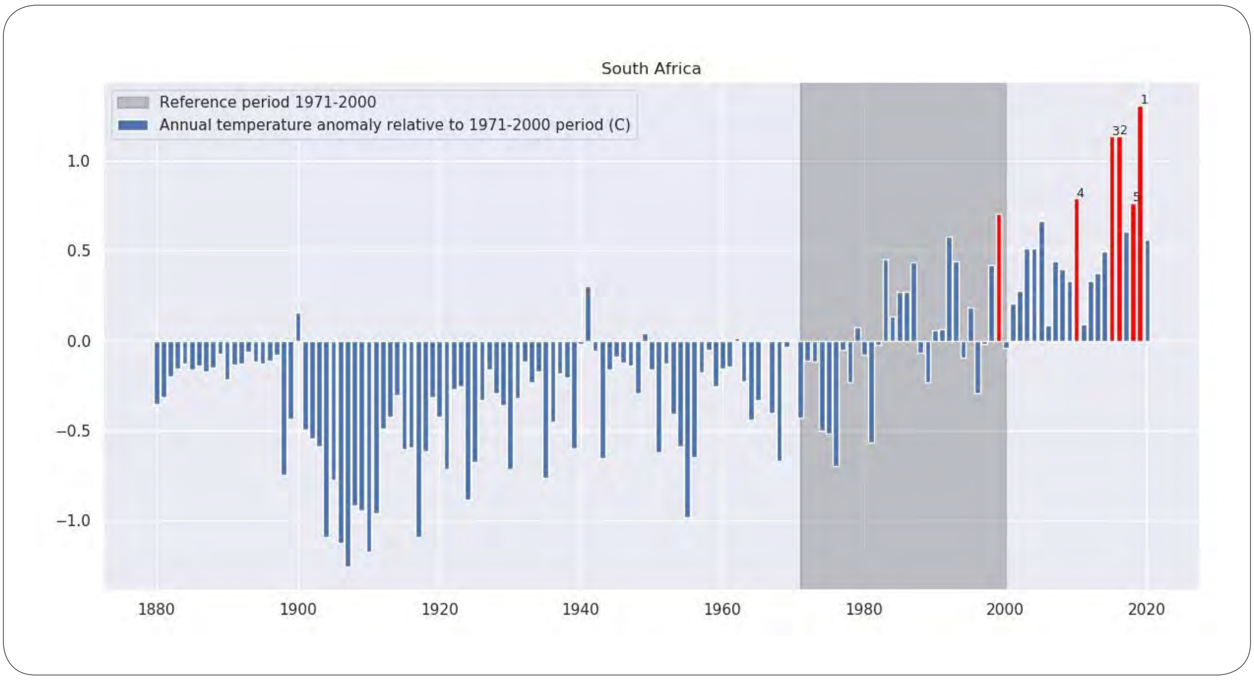


Figure 0.1.1: Average annual temperature anomalies for 1971-2000 for South Africa. The five highest years on record are the red bars numbered 1 to 5.

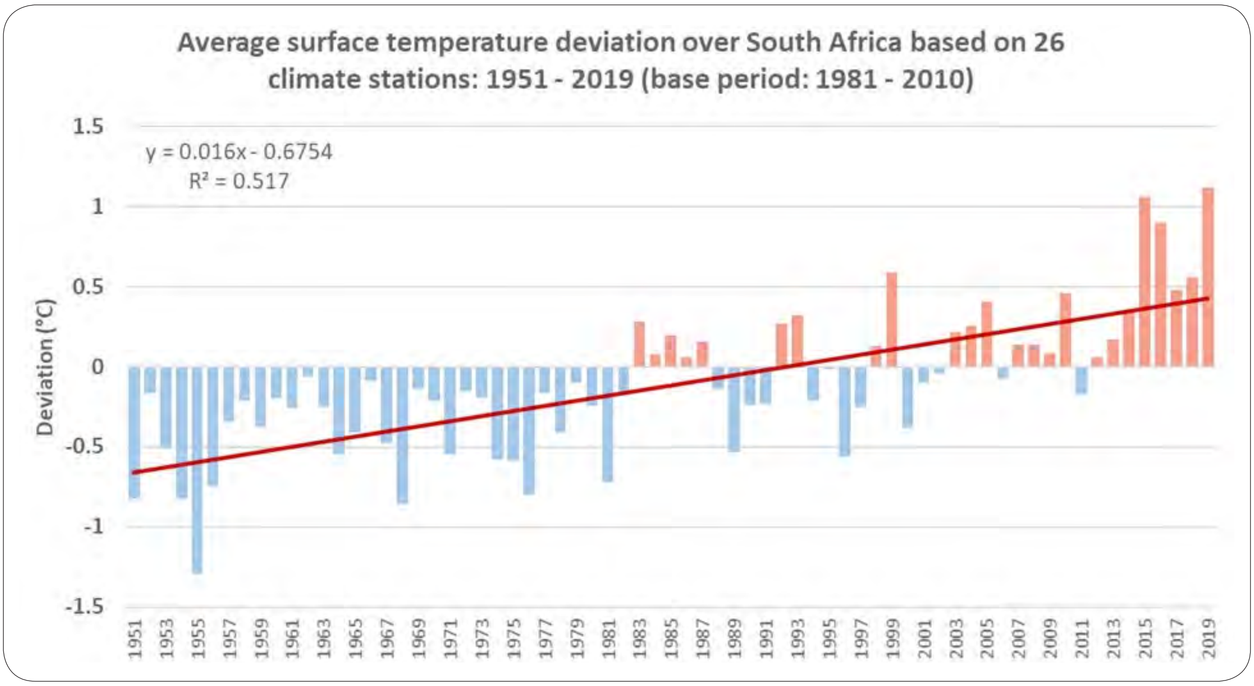


Figure 0.1.2: Average annual temperature anomalies between 1981 and 2010 for South Africa based on homogenised station data from SAWS (SAWS State of the Climate 2019).

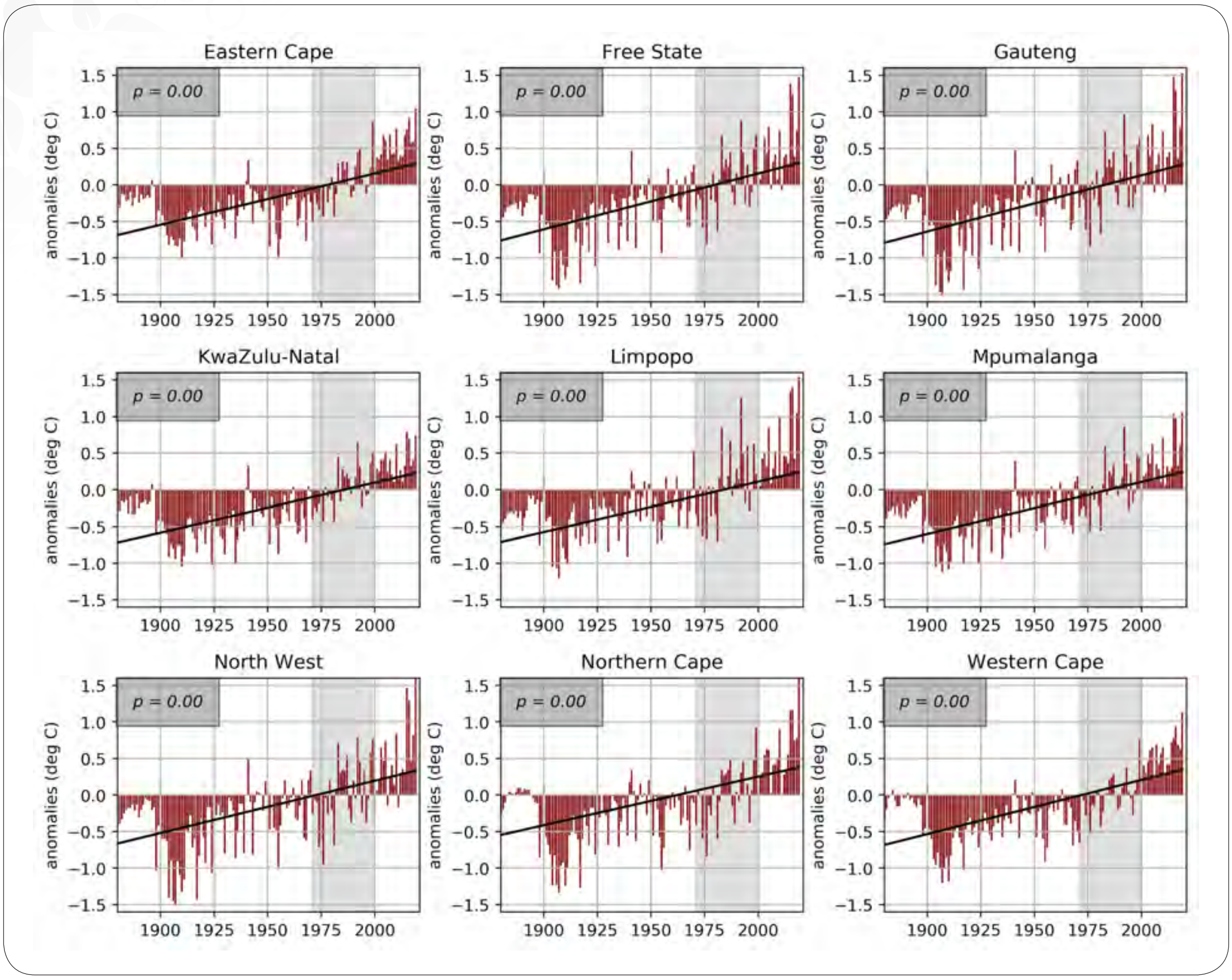


Figure 0.1.3: Average annual temperature anomalies per province from 1971-2000. The trend (black line) and significance level (p) were calculated using the Theil-Sen estimator method.

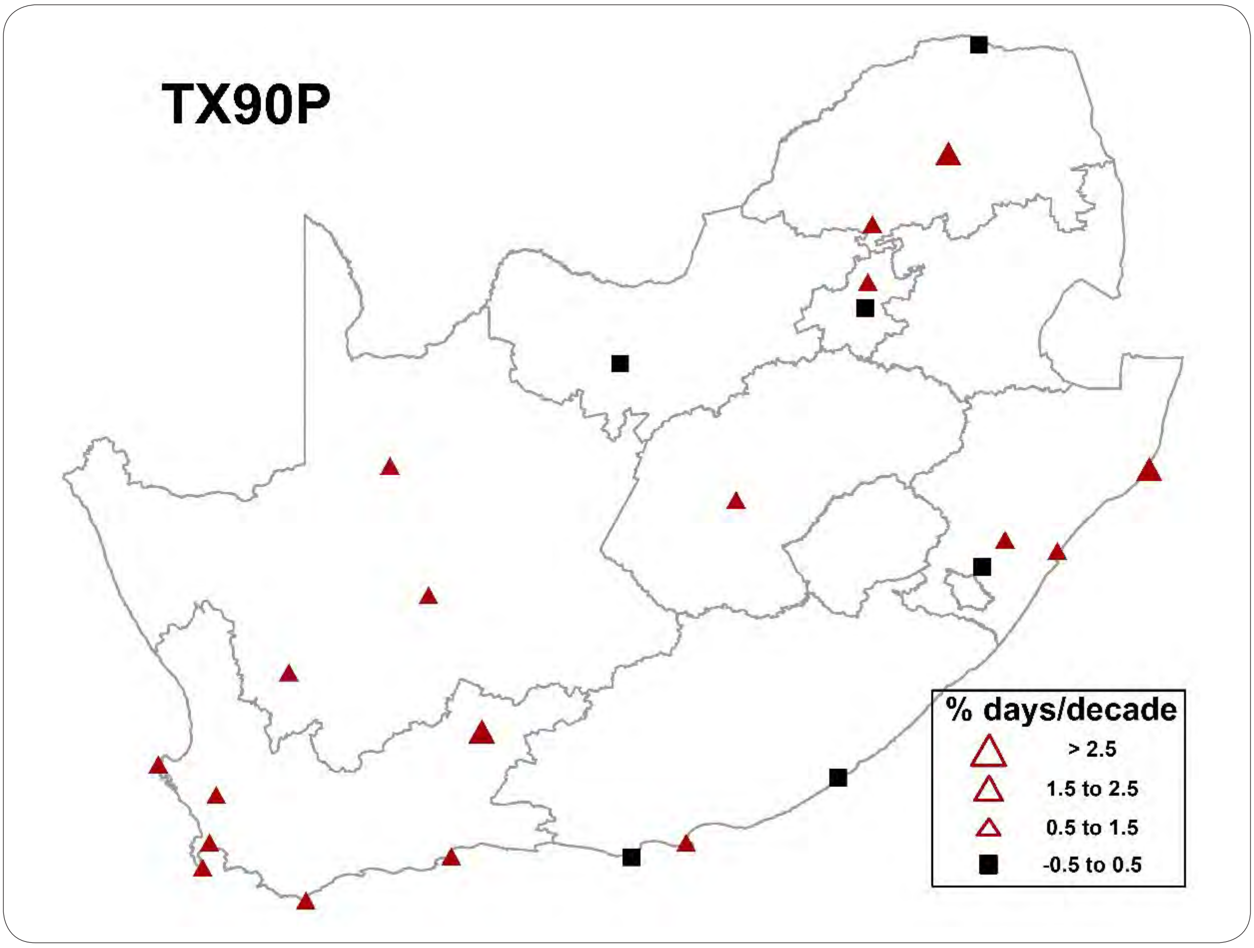


Figure 0.1.4: Trends in hot days: TX90P (% days when maximum daily temperature exceeds the 90th percentile daily temperature) for the period 1931-2019 in % days per decade (filled triangles denote significant trends at the 5% level).

Analysis

Analysis of historical temperature records provides a strong and confident narrative of increasing temperatures with the rate of increase itself increasing over the past several decades. South Africa's temperatures strongly track global temperature increases, with larger rates of warming over the interior provinces, and more moderate warming over KwaZulu-Natal, Eastern Cape and Western Cape.

Analysis of the frequency of very hot days (days > 95th percentile), as calculated by SAWS, demonstrates that across all provinces the number of hot days per year is consistently increasing.

Data

Data is too large to be presented in tabular form.

Data notes

NOAA GlobalTemp dataset which is based on the Global Historical Climate Network station data archive/stream re-gridded to 5° (approximately 500km) spatial resolution.

Data sources

Zhang, H.-M., B. Huang, J. Lawrimore, M. Menne, Thomas M. Smith, NOAA Global Surface Temperature Dataset (NOAAGlobalTemp), Version 4.0. NOAA National Centers for Environmental Information. doi:10.7289/V5FN144H

SAWS, State of Climate Report 2019

Indicator status and recommendations for the way forward

Tier 1

Comment: As noted above, the underlying data should ideally be replaced by local observations managed by SAWS and suitably quality controlled and processed (homogeneity testing etc.). Further, more complex analysis of temperature extremes should be considered that better represent events including length of heat extremes, minimum as well as maximum temperatures and spatial extent of events.

INDICATOR 0.2: ANNUAL TOTAL RAINFALL

0.2

Indicator definition

Total annual rainfall as a percentage of historical averages per province.

Indicator rationale

Total seasonal rainfall is an important driver of agriculture and water availability across the country. Rainfall deficits have direct impacts on both and secondary impacts across a wide range of economic activities. While large scale averages of annual rainfall can hide more local-scale anomalies, they do provide a high-level perspective on a primary climate hazard.

Data visualisation

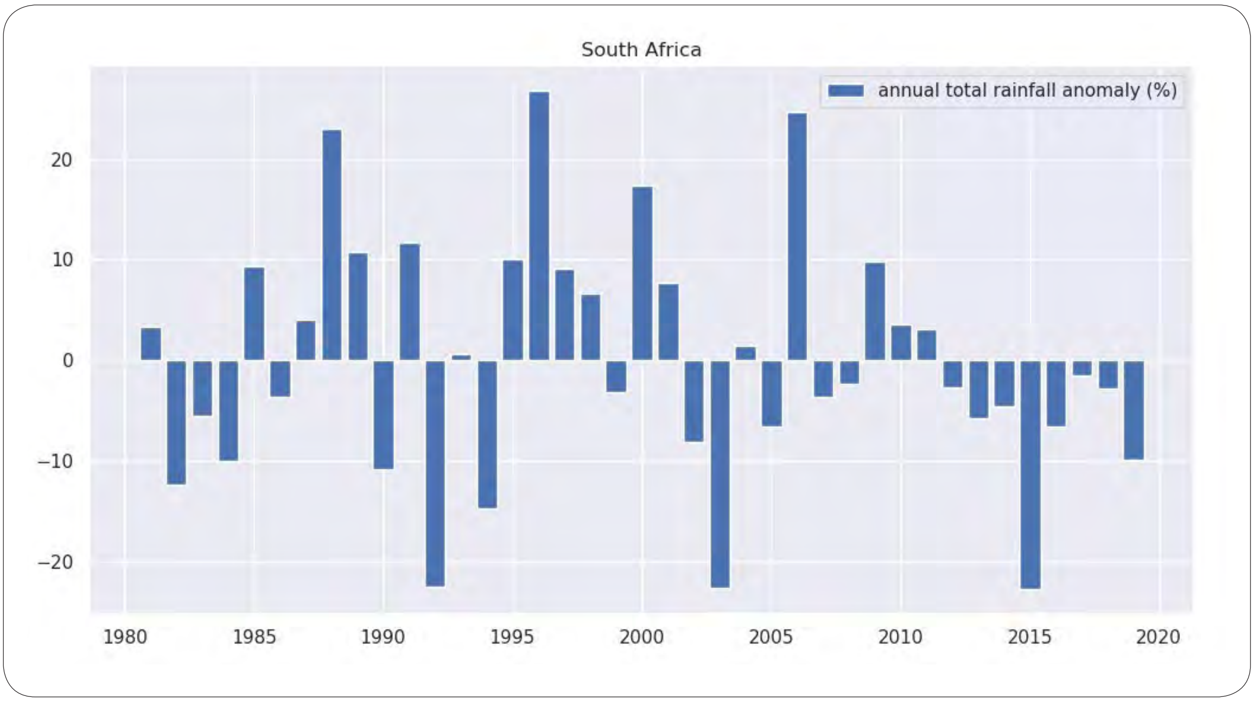


Figure 0.2.1: Total annual rainfall as percentage of historical averages (1981-2010).

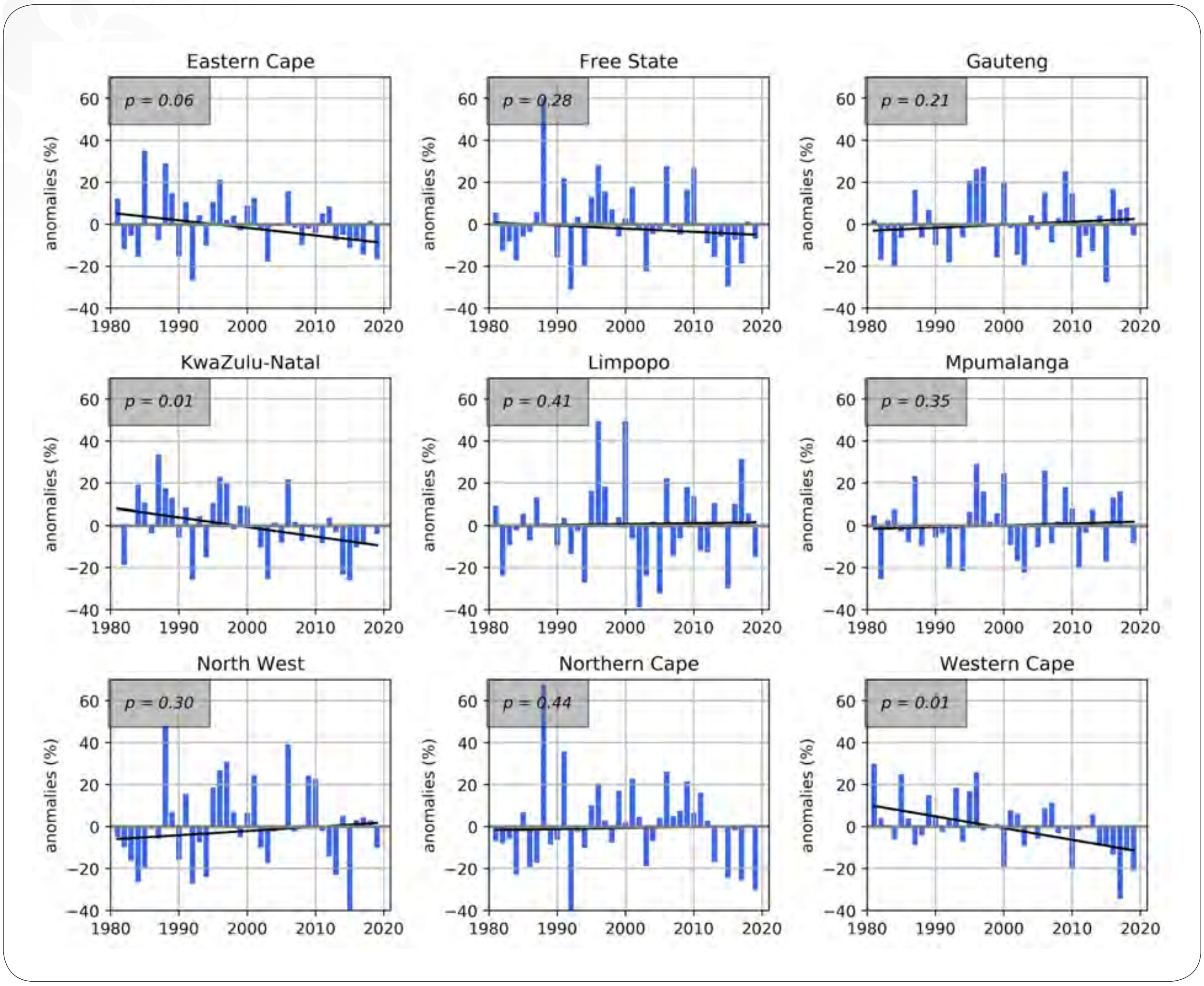


Figure 0.2.2: Total annual rainfall as percentage of historical averages (1981-2010) for July-June for all provinces except Western Cape (Jan-Dec). The trend (black line) and significance level (p) were calculated using the Theil-Sen estimator method.

Analysis

The whole country experienced below normal rainfall since 2012 with 2015/2016 particularly dry, related to the strong El Niño event of that period. While some provinces have recovered to some extent since 2016 (Mpumalanga, North West, Gauteng, Limpopo), others have remained consistently dry. Strong inter-annual variation is evident in all provinces and KwaZulu-Natal, Eastern Cape and Western Cape all have statistically negative trends in total annual rainfall over the full 1981-2019 period.

This indicator links to the urban water resource indicator 5.3 which indicates rainfall deficits. This indicator also links to the drought (SPEI) indicator 3.1 which indicates dry conditions over the past five years.

Data

Data is too large to be presented in tabular form.

Data notes

Total annual rainfall averages were calculated from July-Jun for all provinces except Western Cape which will use January - December.

Data used is the Climate Hazards Group (CHG) InfraRed Precipitation with Station data (CHIRPS) combined satellite and station rainfall estimates. CHIRPS is widely used globally both for research and application. However, the station observation contributions are limited in South Africa and some trends may be inaccurate.

While the CHIRPS data is robust, ideally this indicator should source local data from SAWS as is currently available in the SAWS State of the Climate 2019.

Data Sources

Climate Hazards Group (CHG) Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS). CHIRPS: Rainfall Estimates from Rain Gauge and Satellite Observations. Retrieved from https://www.chc.ucsb.edu/data/chirps/

Indicator status and recommendations for the way forward

Tier 1

0.3 INDICATOR 0.3: ANNUAL RAINFALL EXTREMES

Indicator definition

Total annual intense/extreme rainfall days as percentage of historical averages for South Africa and provinces.

Indicator rationale

Intense rainfall is one of the most common climate hazards contributing to negative climate impacts including infrastructure damage, flooding and associated health and quality of life impacts, loss of life, disruption of transport and economic activities, and so on.

Increasing economic and social impacts of extreme rainfall events can be the result of both increases in the intensity and frequency of rainfall events, as well as increasing exposure and vulnerability. For example, informal settlements in urban areas are often more exposed to extreme rainfall due to lack of infrastructure and location in unsuitable areas such as river flood zones and wetlands.

Tracking the frequency of intense/extreme rainfall is therefore an important component of understanding recent trends in extreme rainfall-related impacts on society.

Data visualisation

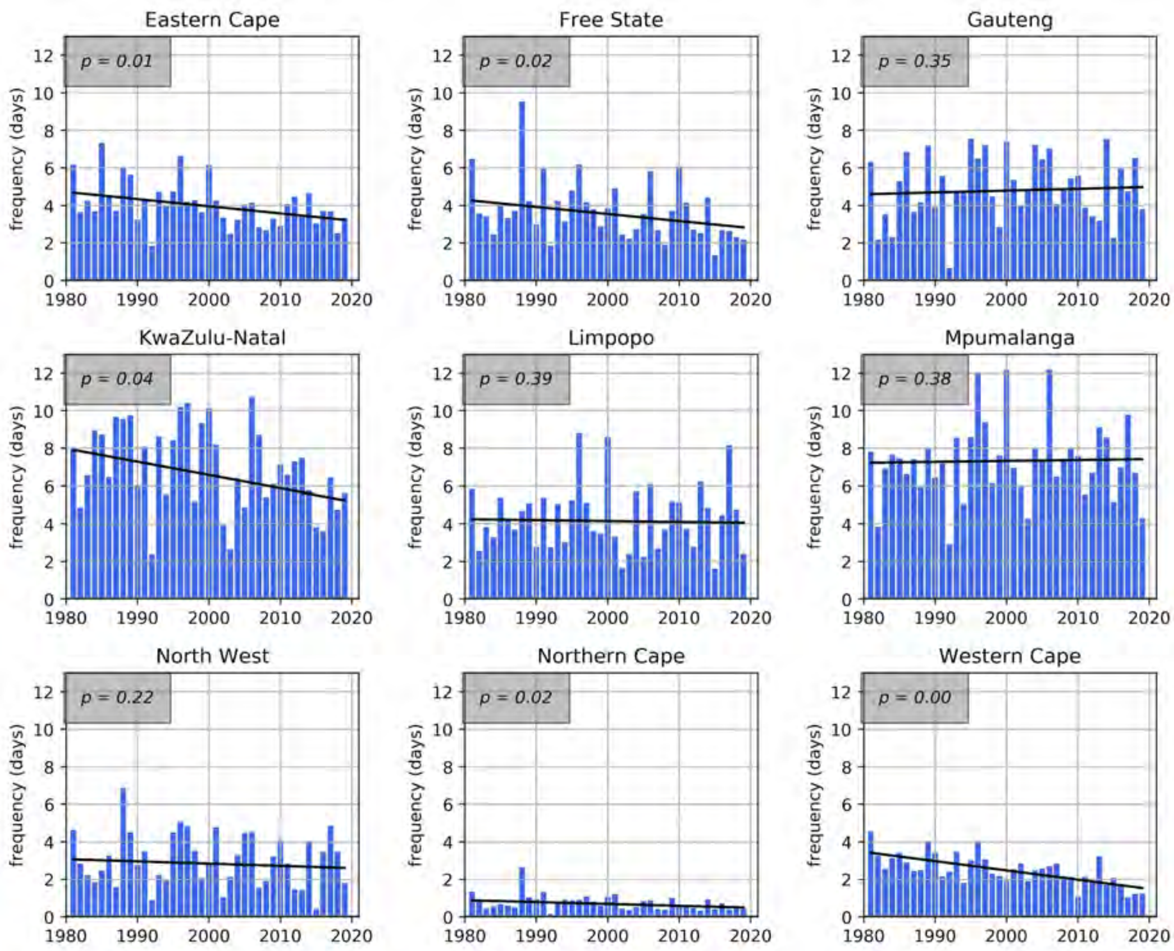


Figure 0.3.1: Frequency of extreme rainfall days (days with rainfall above the 95th percentile) per year. The trend (black line) and significance level (p) were calculated using the Theil-Sen estimator method.

Analysis

In agreement with recent publications, there are no recent strong trends in intense rainfall events across most of South Africa, but some areas where drying trends are apparent, such as the Western Cape, Eastern Cape, and KwaZulu-Natal, show some statistically significant negative trends in the frequency of extreme rainfall events.

The results above suggest that the increasing impact of intense rainfall may be related more to increased exposure and vulnerability rather than increased frequency of intense rainfall events. However, this conclusion is qualified by the scale and simplicity of this analysis. Extreme rainfall events are often spatially very localised and of short duration. Such events will (a) not always reflect in observed data records from weather stations and even satellite proxy data, and (b) not strongly influence provincial-scale statistics.

Data

Data is too large to be presented in tabular form.

Data notes

Rainfall extremes were calculated from July-June for all provinces except Western Cape which will use January-December.

For this indicator the 95th percentile threshold is used to identify intense rainfall. This categorises daily rainfall of magnitude greater than the 95th percentile of all rain days' magnitudes as intense or extreme.

It is noted that the CHIRPS data is a combination of station observations and satellite proxy estimates. While CHIRPS has been used extensively and is well tested and validated against other datasets, the nature of extreme rainfall events is that they are often spatially local and of short time duration (an hour or less). Such events may not reflect accurately in a dataset such as CHIRPS. In general, these events are hard to observe consistently.

Additionally, this analysis should be based on locally-sourced data from SAWS. SAWS already produces this analysis for the upcoming WMO Climate Extremes report and this can be included in future iterations of this report.

Data sources

Climate Hazards Group (CHG) InfraRed Precipitation with Station data (CHIRPS). CHIRPS: Rainfall Estimates from Rain Gauge and Satellite Observations. Retrieved from https://www.chc.ucsb.edu/data/chirps/

Indicator status and recommendations for the way forward

Tier I

Comment: As noted above, alternative approaches to identifying localised short duration extreme events should be explored. Averaging across provincial scales is useful but it is possible that methods could be developed that identify specific events and their characteristics in a way that is more informative.

INDICATOR 0.4: SEA SURFACE TEMPERATURE ANOMALIES

Indicator definition

The persistence and frequency of sea surface temperature (SST) anomalies in the South African marine territorial waters.

Indicator rationale

The oceans influence weather and climate by absorbing solar radiation, distributing heat around the globe and driving weather systems. Ninety percent of the increased heat associated with global climate change is taken up and stored in the oceans. As a result, ocean surface temperatures have shown a long-term warming trend since the mid-19th century (IPCC, 2014) driving changing weather patterns by providing increased energy and moisture to the atmosphere (IPCC, 2014). Local SST changes also reflect shifts in wind regimes. Direct impacts on the marine environment are also observed, including species migrations and degradation of ecosystems. Tracking SST anomalies in South Africa's marine environment is therefore an important informant on global climate changes as well as associated impacts in the South African marine and terrestrial environments. SST anomalies, in particular, give a good indication of changes in localised circulation such as upwelling and mixing which can indicate or lead to changes in other marine variables.

Data visualisation

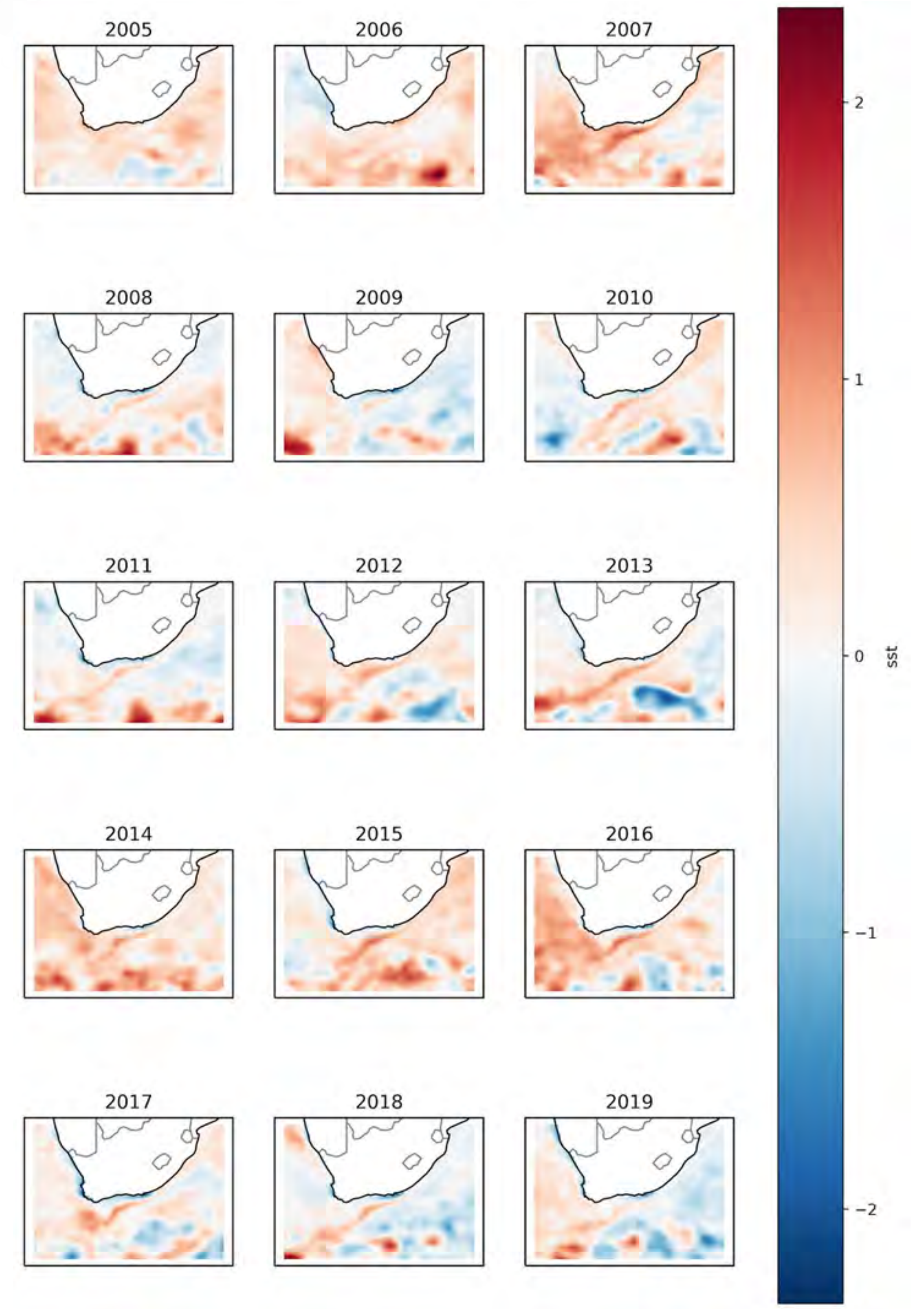


Figure 0.4.1: Spatial plots of the annual mean sea surface temperature anomalies (°C) for the last 15 years. Anomalies calculated from the 30-year climatology (1982-2011).

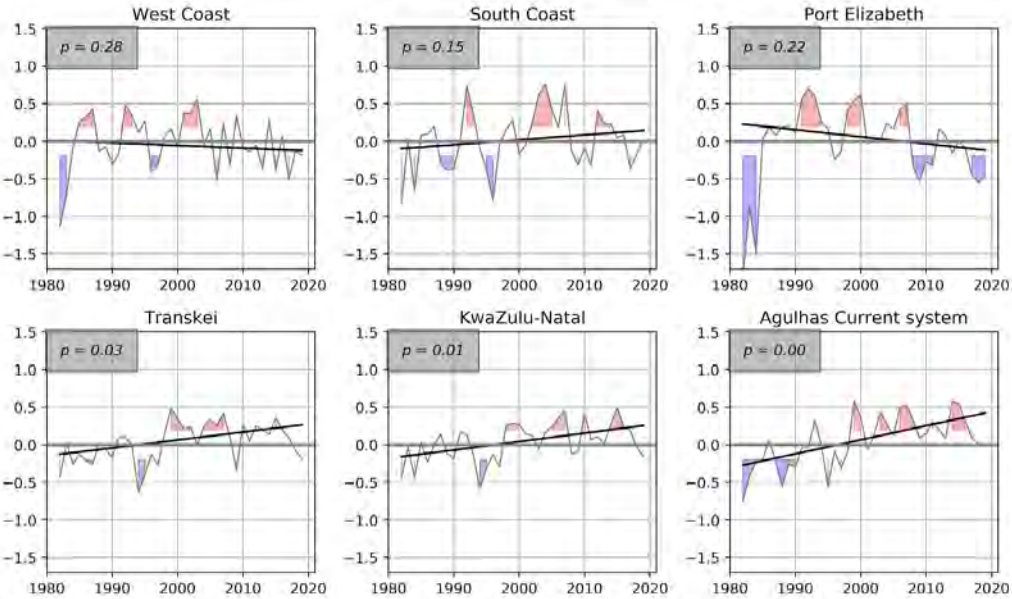


Figure 0.4.2: Sea surface temperature anomalies (°C) for the five coastal zones and the large Agulhas Current system zone. Anomalies calculated from the 30-year climatology (1982-2011). The trend (black line) and significance level (p) were calculated using the Theil-Sen estimator method.

Analysis

Annual mean sea surface temperatures show complex patterns of anomalous warming or cooling over the domain and these patterns change significantly from year-to-year. Results for the five coastal zones and the large Agulhas Current system area also show the strong variations from year to year. Warming trends are evident in the Eastern Cape and KwaZulu-Natal coastal zone, and especially the Agulhas Current system area. However, this trend is over the relatively short (1981-2019) period and could be related to longer-term variability across decades.

Data

Data is too large to be presented in tabular form.

Data notes

The NOAA Optimum Interpolate Sea Surface (OISS) temperature provides daily global ocean coverage at a quarter degree resolution from September 1981 to present. Daily sea surface temperatures were downloaded for the period 1982 to 2019. The daily anomalies were calculated relative to a 30-year climatology (1982-2011) and then averaged to form annual anomalies. The analysis was performed on a regional domain (24° - 42° S, 12° - 36° C) and six smaller domains following those used in the paper by Rouault *et al.* (2010).

- West Coast: 30° - 33° S, 16.75° - 18.5° E
- South Coast: 34° - 35° S, 20° - 23° E
- Port Elizabeth / Port Alfred: 33.75° - 34.75° S, 24° - 27° E
- Eastern Cape: 30° - 33° S, 29° - 30.5°
- KwaZulu-Natal: 26.5° - 29.75° S, 31° - 33.75° E
- Agulhas Current system: 36° - 42° S, 15° - 30° E

Data sources

Reynolds, Richard W., Thomas M. Smith, Chunying Liu, Dudley B. Chelton, Kenneth S. Casey, Michael G. Schlax., 2007. Daily High-Resolution-Blended Analyses for Sea Surface Temperature. J. Climate, 20, 5473-5496. Retrieved from https://www.esrl.noaa.gov/psd/data/gridded/data.noaa.oisst.v2.highres.html [Accessed 10 Feb. 2020]

Indicator status and recommendations for the way forward

Tier I

INDICATOR 0.5: WIND ANOMALIES

0.5

Indicator definition

Anomalies in coastal wind direction and intensity in the west coast of South Africa.

Indicator rationale

Wind is considered important for hydrodynamics, water mixing, waves and air quality. Changes in coastal winds can result in significant impacts on the coastal marine and terrestrial environments. For example, on the west coast of South Africa, coastal winds drive upwelling in the Benguela Current which brings cold, nutrient-rich water to the surface, driving primary production (phytoplankton) which supports abundant fisheries and other marine life. This biodiversity-rich habitat forms the basis for an economically significant fisheries sector. Therefore, changes in the patterns of upwelling-favourable winds can affect trends across and within ecosystems (Sydeman *et al.*, 2014). Increase in wind velocity and wave height are projected consequences of climate change along South African coasts. Constant monitoring of coastal winds is therefore necessary.

Data visualisation

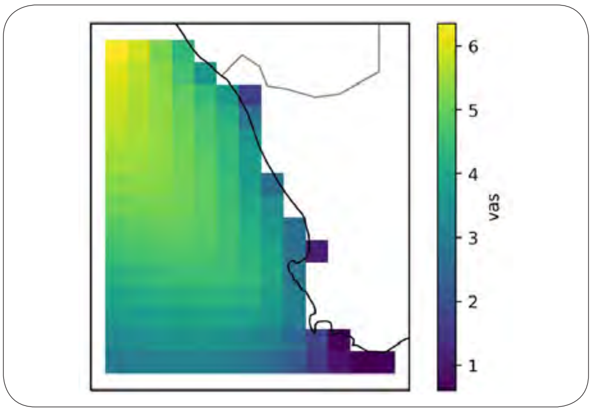


Figure 0.5.1: Climatology of 10 metre zonal (north-south) wind component 1981-2010 (units m/s).

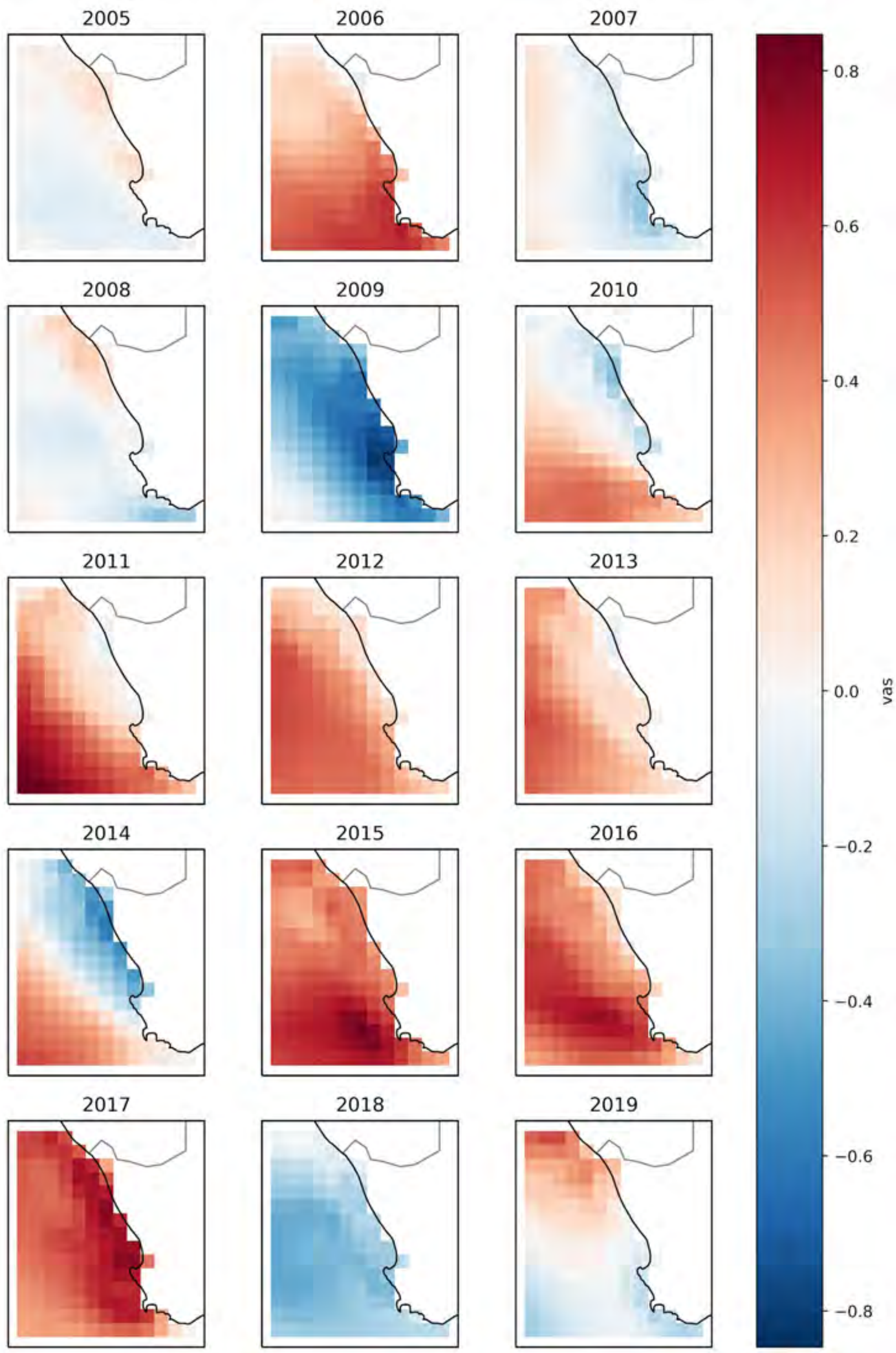


Figure 0.5.2: Annual anomalies in 10 metre zonal (north-south) wind components from 2005 to 2019 (units m/s).

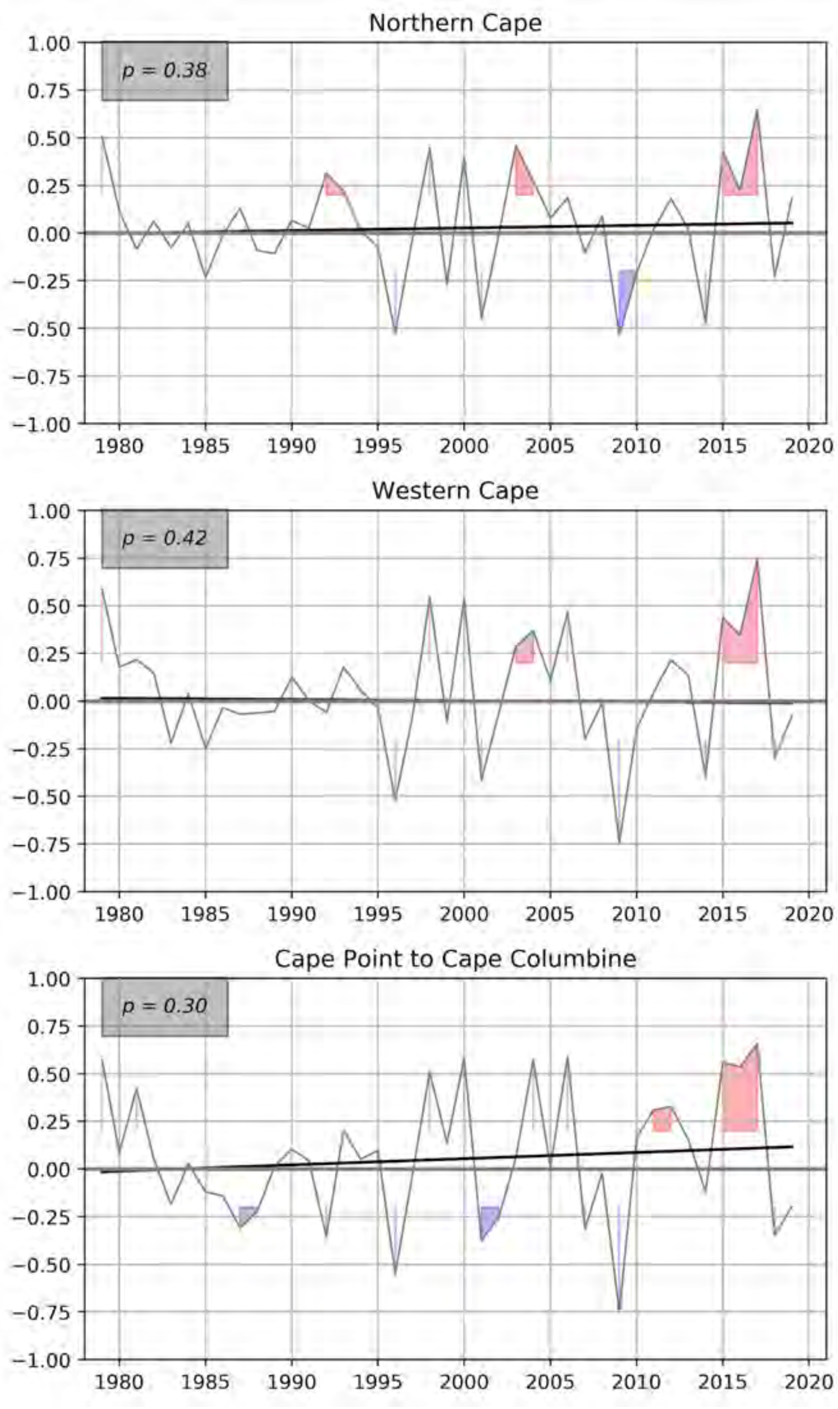


Figure 0.5.3: Time series (1979-2019) of the annual mean anomalies in the 10 metre zonal (north-south) wind component for three zones along the west coast of South Africa. The trend (black line) and significance level (p) were calculated using the Theil-Sen estimator method.

Analysis

The climatology of the 10 metre zonal wind component shows that the dominant wind direction is from the south over the full west coast ocean domain, but that the strength of the southerly wind vector is strongest offshore to the north and weakest along the south coast (note, this is only the north-south component of the wind and therefore does not present the actual wind speed).

The strength of the southerly wind component varies from year-to-year by as much as 0.8 m/s in some parts. The southerly wind component was stronger than average during 2017 and weaker than average in 2018 along the full west coastal zone, but in 2019, the wind was stronger than average over the northern parts, and weaker over the southern part of the study area.

No statistically significant trends in the zonal wind annual anomalies are evident at the annual scale for any of the three west coast zones.

Data

Data is too large to present in tabular form.

Data notes

This initial indicator just focuses on the west coast of South Africa and analyses the zonal, or north-south, component of the wind.

Tracking the anomalies in coastal wind direction and intensity is complex. Local conditions, such as the shape and direction of the coast, play a significant role in modulating the coastal wind. Also, the duration and fetch of the wind strongly determines if the wind enhances or suppresses upwelling along the coast. This is an area of ongoing current research, but for now this indicator just explores the variation from year-to-year in the north-south component of the wind (10m zonal wind component).

The northward component of the 10m wind is the horizontal speed of air moving towards the north, at a height of ten metres above the surface of the Earth, in metres per second. The wind data is from the hourly ERA5 global reanalysis product which has a horizontal resolution of 0.25° and covers the period from 1979 to present. The data was averaged from hourly to annual scale and then the annual values were differences from the long-term climatology (1981-2010) to produce annual average 10m wind vector anomalies in metres per second.

Data sources

Copernicus Climate Change Service (C3S), 2018. ERA5 hourly data on single levels from 1979 to present: *Northward component of the 10 meters wind*. (10m u-component of wind). Copernicus Climate Change Service Climate Data Store (CDS). Retrieved from https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single- levels?tab=overview [Accessed 10 Feb. 2020]

Indicator status and recommendations for the way forward

Tier 3

Comment: As noted, this is a simple preliminary indicator that only just explores the north-south component of the wind over the west coast of South Africa. A more detailed analysis could be undertaken for sites identified as important. The indicator could be expanded to include wind speed and direction at different times of the year and could also be expanded to explore ocean/wave attributes such as wave direction and height.

INDICATOR 0.6: AMBIENT CARBON DIOXIDE (CO_2) CONCENTRATION

Indicator definition

Global and local change in the near surface ambient carbon dioxide (CO_2) concentration through time.

Indicator rationale

Human activities, including the burning of fossil fuels and land use changes, are changing atmospheric concentrations of carbon dioxide (CO_2). CO_2 is a key greenhouse gas, contributing to global warming and climate change.

Ambient CO_2 reflects large-scale well-mixed concentrations rather than localised transient concentrations from specific pollution sources. This is the standard measure of global CO_2 measurement.

Data visualisation

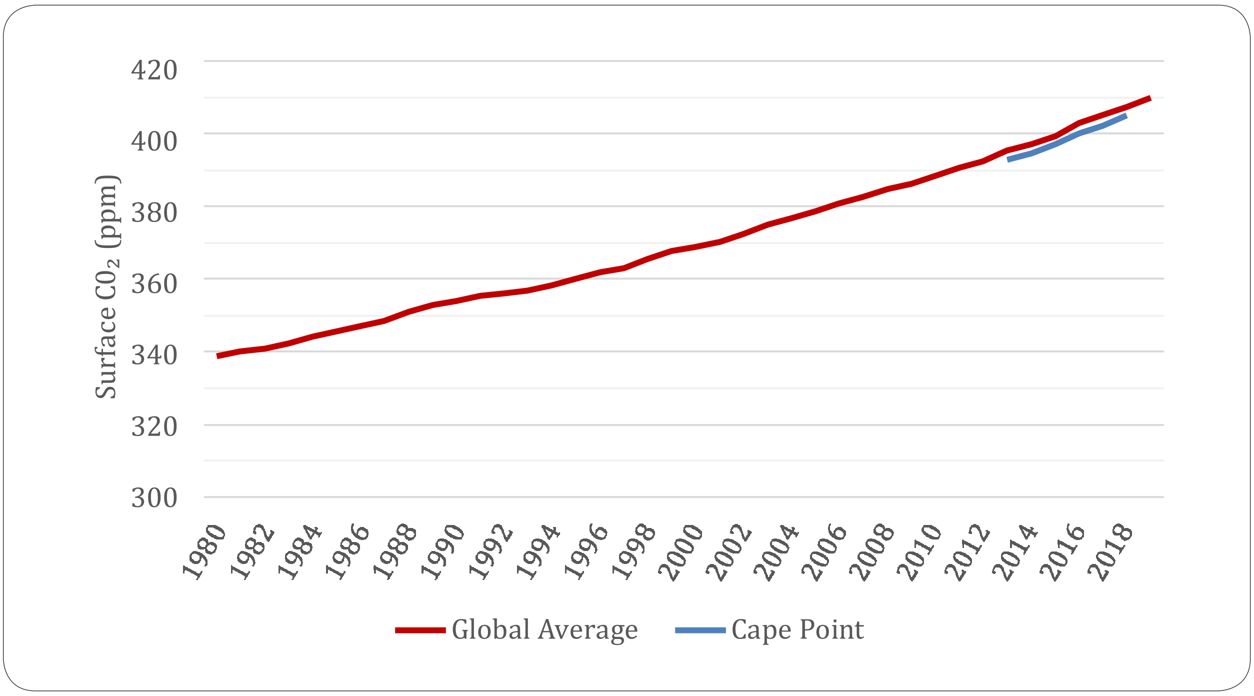


Figure 0.6.1: Surface CO_2 concentrations in parts per million (ppm), global average versus Cape Point station measurements.

Analysis

There is a distinct increase in global average CO_2 concentrations, with an increase of around 70 parts per million (ppm) globally over the last 40 years. The Cape Point data, while based on a shorter time series, seems to follow the global trends closely.

Data

Table 0.6.1: Surface CO_2 concentrations in parts per million (ppm), global average versus Cape Point station measurements.

	Global Average	Cape Point
1980	338,8	
1981	340	
1982	340,76	
1983	342,44	
1984	343,99	
1985	345,47	
1986	346,87	
1987	348,62	
1988	351,15	
1989	352,8	
1990	353,98	
1991	355,29	
1992	355,99	
1993	356,71	
1994	358,2	
1995	360,04	
1996	361,79	
1997	362,9	
1998	365,54	
1999	367,64	
2000	368,84	
2001	370,41	
2002	372,42	
2003	374,96	
2004	376,8	
2005	378,81	
2006	380,94	
2007	382,68	
2008	384,78	
2009	386,29	
2010	388,57	
2011	390,45	
2012	392,46	
2013	395,19	392,77
2014	397,12	394,73
2015	399,41	397,19
2016	402,86	400,16
2017	405	402,38
2018	407,38	405,03
2019	409,83	

Data notes

Cape Point is part of the Cooperative Global Air Sampling Network and follows all the protocols and standards required. It also samples air from the southern ocean regions so is more reflective of large-scale ambient CO_2 concentrations rather than localised and transient pollution sources.

Data sources

Cape Point Data - Dlugokencky, E.J., J.W. Mund, A.M. Crotwell, M.J. Crotwell, and K.W. Thoning (2019), Atmospheric Carbon Dioxide Dry Air Mole Fractions from the NOAA ESRL Carbon Cycle Cooperative Global Air Sampling Network, 1968-2018, Version: 2019-07, https://doi.org/10.15138/wkgj-f215.

Global Data - Dlugokencky, E.J., and Tans, P., 2020. NOAA/ESRL (www.esrl.noaa.gov/gmd/ccgg/trends/), Trends in Atmospheric Carbon Dioxide - Global, Globally averaged marine surface annual mean data [Data file]. Retrieved from ftp://aftp.cmdl.noaa.gov/products/trends/co2/co2_annmean_gl.txt [20/4/2020]

Indicator status and recommendations for the way forward

Tier I

ANALYSIS AND REFLECTION ON INDICATORS IN THE CLIMATE NARRATIVE

Global narratives of climate change are supported by increasingly strong evidence of changing climate and ocean variables, associated increasing CO_2 concentrations, as well as resultant socio-economic impacts. However, understanding these narratives in a local context is often challenging. Regional and local climates, while influenced by global trends, are also subject to natural variability such as El Niño-Southern Oscillation (ENSO) cycles which produce cycles of wet and dry conditions somewhat unrelated to climate change.

Additionally, identifying changes in climate and ocean variables that relate substantively to potential socio-economic impacts requires a deep understanding of local and regional systems. For example, the impact of climate change on fisheries is a complex interaction between ocean temperatures, wind regimes, ocean geo-chemistry, etc. These system dynamics are seldom well understood.

The climate and ocean indicators detailed here provide an over-arching narrative of regional climate and ocean change with some primary relevance to the South African socio-economic system. They clearly indicate trends of increasing temperatures and temperature extremes, high rainfall variability with some provinces (Western Cape) demonstrating long-term drying trends while many areas demonstrate only marginal long-term trends. While increases in extreme rainfall events are anticipated there is as yet little evidence of such changes over South Africa. This does not preclude future increases and is qualified by the fact that identifying robust trends in rare/extreme events requires very long data time series, which we do not have access to in this reporting process.

Changes in ocean temperatures and wind regimes are complex and demonstrate high natural variability. While average ocean temperatures are increasing in many regions around the South African coastline, some areas reflect decreasing temperatures which are likely a result of shifting ocean current dynamics. These indicators clearly demonstrate the need for robust data and research at scale and with respect to variables and statistics relevant to socio-economic impacts and decision making.

More impact-relevant indicators such as urban and rural droughts and urban flood damage can be found in the relevant narrative sections.

Finally, access to data is a key limitation in developing and analysing climate indicators. Many of the indicators here draw on internationally collated and managed datasets rather than locally collated and managed datasets. Further advancing the collection, management and shared access to relevant climate and ocean datasets across South African institutions is of key strategic importance.

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IPCC SR15: Hoegh-Guldberg, O., Jacob, D., Taylor, M., Bindi, M., Brown, S., Camilloni, I., ... & Guiot, J., 2018. Impacts of 1.5° C global warming on natural and human systems. In *Global Warming of 1.5° C: An IPCC Special Report on the impacts of global warming of 1.5° C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. IPCC.

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THEMATIC AREA

NARRATIVE I

ECONOMIC STRUCTURE, WORK CREATION AND ECONOMIC GROWTH

Contents

Figures and Tables

INTRODUCTION TO THE ECONOMIC STRUCTURE, WORK CREATION AND ECONOMIC GROWTH NARRATIVE

South Africa has a conjoined 'productivity-growth-unemployment-carbon' problem. In recent times this economic problem has manifested as a state-owned enterprise (SOE), municipal and household debt crisis, as households struggle to pay for basic services in the face of rising electricity prices and economic inefficiency. Given that most greenhouse gases originate from economic activity, and that climate change will have profound economic impacts, South Africa's climate response must be embedded in economic strategy and address problematic attributes of the economy simultaneously if it is to gain traction. In keeping with the findings of Chapter 5 of the Special Report on 1.5°C of warming (IPCC, 2018), an effective climate response must place emphasis on work and livelihood creation for the most vulnerable.

In the last South African recession (2008/09), the economy lost more jobs per unit of economic contraction than it had created when it grew by the same amount in previous periods. One of the underlying reasons for South Africa's disproportionate job-shedding during the recession, and subsequent difficulty in re-establishing growth and jobs, relates to the structure of the economy. Concentration of South Africa's economic influence in the capital intensive 'minerals-energy complex' and reliance on coal, gold and platinum group metal (PGM) mines, and heavy industry linked to the automobile and metals sectors for exports, has undermined economic diversity and agility. It is an economic structure that, together with South Africa's vertically-integrated electricity monopoly and levels of investment in skills and innovation that remain below the average for middle-income countries, has contributed to environmental degradation and seen large portions of the South African labour force stuck in relatively low-skilled primary sector work.

The same economic structure influences South Africa's unusually high greenhouse gas intensity. Per capita emissions in South Africa, once land, cement and energy consumption are included, is estimated at 9 tons per year, up from 7 tons per capita in 1980, in a world where the average is 4.79 tons per capita (World Bank Data, 1960-2014). High per capita emissions are primarily a function of the reliance on low-grade coal for generating over 90% of the electricity that is available to almost all citizens. It is aggravated by energy and capital- intensive primary sector industries and an urban spatial form in which people and goods travel long distances in cars and buses to access markets and economic opportunity. South Africa's declining rail capacity has also made it difficult to cut transport and freight-related emissions. In 2014 every thousand dollars of GDP (adjusted for 2011 purchasing power of parity) produced by South Africa required the emission of 0.68 tons of CO_2 (World Bank Data, 1990-2014). This is down from 1.35 tons in 1990, but more than double the world average of 0.34.

The implications of South Africa's carbon intensity are becoming more acute as the global economy begins to factor in the risk of climate change and the full cost of the anthropogenic greenhouse gases that are driving the change. In 2019, the World Economic Forum ranked South Africa 114 out of 115 countries in terms of 'energy transition' risk, and the prospects of South Africa's economic competitiveness in a carbon-constrained global economy, present reasons for concern (WEF, 2019). South Africa's balance of payments, and associated economic stability, rests on the export of iron ores, gold, ferro-alloys, platinum group minerals, coal and motor vehicle parts, all of which are associated with greenhouse gas intensity. Investment in coal mining and the trading of coal has already become difficult as economies around the world look to curb emissions. On balance South Africa's trade is considered highly exposed to an adjustment in the global economy to prevent climate change. South Africa's greatest import item is petroleum oils and oils obtained from bituminous minerals. Substituting this South African import with a locally sourced renewable energy option, would improve South Africa's balance of payments, but by less than the contribution of coal and platinum group metals (PGM) to exports. In addition, South Africa's agricultural sector (itself an export revenue earner) will be impacted by shifting weather patterns, creating further balance of payments disruptions.

The 'transition risk' to which South Africa is exposed is a function of more than carbon intensity, and speaks to the risk that accompanies the structural, technological and social transition to a low-carbon and climate-resilient economy (WEF, 2019). Analysis by the Climate Policy Initiative in 2019 suggested that the risk of the transition could be ZAR2 trillion ($124 billion) between 2013 and 2035, and that most of this risk would be felt by the mid-2020s, highly concentrated in the coal sector, Eskom and Sasol. Factors contributing to South Africa's lack of economic agility, and associated risk in the face of climate change, include:

- Socio-economic inequality (high Gini coefficient and Theil Index) which makes reaching consensus positions on policy difficult given the divergent needs and aspirations of different segments of the population.
- South Africa's status as a small, economically open and integrated economy. South Africa does not have an economy the size of China (or Brazil or India) and has much weaker bargaining power in global trade negotiations. This translates into a perceived inability to create the scope for innovation and transformation without risking capital flight (when assets or money rapidly flow out of the country).
- The geography of the country and the fragmented and sprawling nature of South Africa's major cities which, together with low levels of public transport, create car and fossil fuel dependence.

Significantly, these factors overlap with the economic attributes inhibiting growth, employment creation, economic inclusion and support for small businesses. The net impact is that it is difficult for South Africans and South African companies to decouple their activities from fossil fuels and it will become increasingly more difficult for companies to grow and create employment as climate change begins to impose economic constraints. This observation focuses attention on the need to reform the structure and composition of the South African economy as part of efforts to reduce emissions and increase resilience to climate impacts. It also highlights the potential of South Africa's climate response to support much needed inclusive economic growth and employment.

Against this backdrop, an appropriate set of climate indicators must shed light on the relationship between economic structure, employment, growth, wage and income inequality (defined by race, gender and geography) and greenhouse gas emissions. Indicators need to recognise this and report emissions in terms of their relationship with economic growth, investment, employment, socio-economic inequality and the sectoral concentration of the economy. These indicators will assist in developing and guiding policies to unlock the employment and social inclusion economic growth potential that accompanies South Africa's climate response.

1.1 INDICATOR 1.1: JOBS PER UNIT OF GHG EMISSIONS

Indicator definition

Total number of people employed on a full-time or part-time basis relative to national greenhouse gas emissions.

Indicator rationale

The indicator tracks progress in addressing the twin challenge of work creation and decarbonisation, both of which are central to a 'just transition'. The indicator assumes that access to work is a key component of development, dignity and inclusive economic growth. The indicator accommodates the idea that efforts to reduce emissions in South Africa could, contrary to the public narrative, be linked to new employment opportunities and higher levels of employment particularly where these efforts redress structural barriers (skill and spatial disconnects, as well as economic concentration in capital intensive industries) in the national economy.

Data visualisation

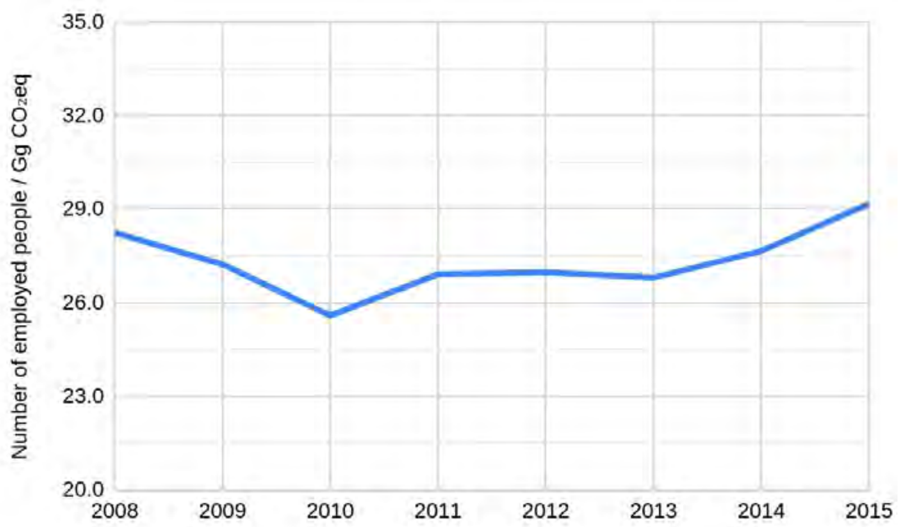

Figure 1.1.1: Labour intensity of emissions. Ratio of total number of people employed in South Africa to annual national GHG emissions.

Analysis

The indicator shows that employment intensity of emissions improves after 2013 but remains below 2008 (pre-financial crisis) levels. If you consider the GDP trend and the carbon intensity of GDP (1.2) then the improvement appears to have been driven by higher levels of GDP per unit of emissions, more than employment gains. The increasing contribution of the services industry to South Africa's economy is an important part of this trend. The trend is encouraging in that it suggests that lower-carbon growth can be labour intensive. However, South Africa continues to employ relatively few people per ton of emissions. Brazil, for example, is twice as labour intensive as South Africa, with almost 70 people employed per Gg of CO_2eq of GHG emissions and in the United Kingdom 91 people are employed per Gg of CO_2eq of GHG emissions.

Data

Table 1.1.1: Ratio of total number of people employed in South Africa to the annual national GHG emissions.

	People / Gg CO_2 equivalent
2008	28.3
2009	27.2
2010	25.6
2011	26.9
2012	27.0
2013	26.8
2014	27.7
2015	29.2

Data notes

The number of people employed includes those employed on a full-time and a part-time basis.

In the GHG National Inventory Report 2017, the Global Warming Potentials (GWPs) from the IPCC Second Assessment Report (SAR) were applied to be compliant with UNFCCC reporting requirements.

Data sources

Department of Environmental Affairs, (2017) GHG National Inventory Report South Africa 2000-2015. Retrieved from https://www.environment.gov.za/sites/default/files/reports/

Statistics South Africa, (2008 - second quarter 2019) Quarterly Labour Force Survey (QLFS) Trends. Retrieved from http://www.statssa.gov.za/

Indicator status and recommendations for the way forward

Tier I

1.2 INDICATOR 1.2: CARBON INTENSITY OF GDP

Indicator definition

National greenhouse gas emissions against the national GDP over time.

Indicator rationale

The indicator tracks 'carbon productivity', and South Africa's efforts to decouple its economy from greenhouse gas emissions in order to retain competitiveness and protect access to export markets, jobs and macro-economic stability. The IPCC (2018) suggests that a 66% chance of avoiding catastrophic climate change requires carbon neutrality by 2050. Ultimately South Africa will need to structure its economy to align emissions with the global effort to cut emissions by half by 2030 and be carbon neutral by 2050, or face the punitive measures imposed on emission-intensive countries by the global effort to prevent climate change. In South Africa, this indicator can be applied at the metropolitan municipality scale as well as at the country scale.

Data visualisation

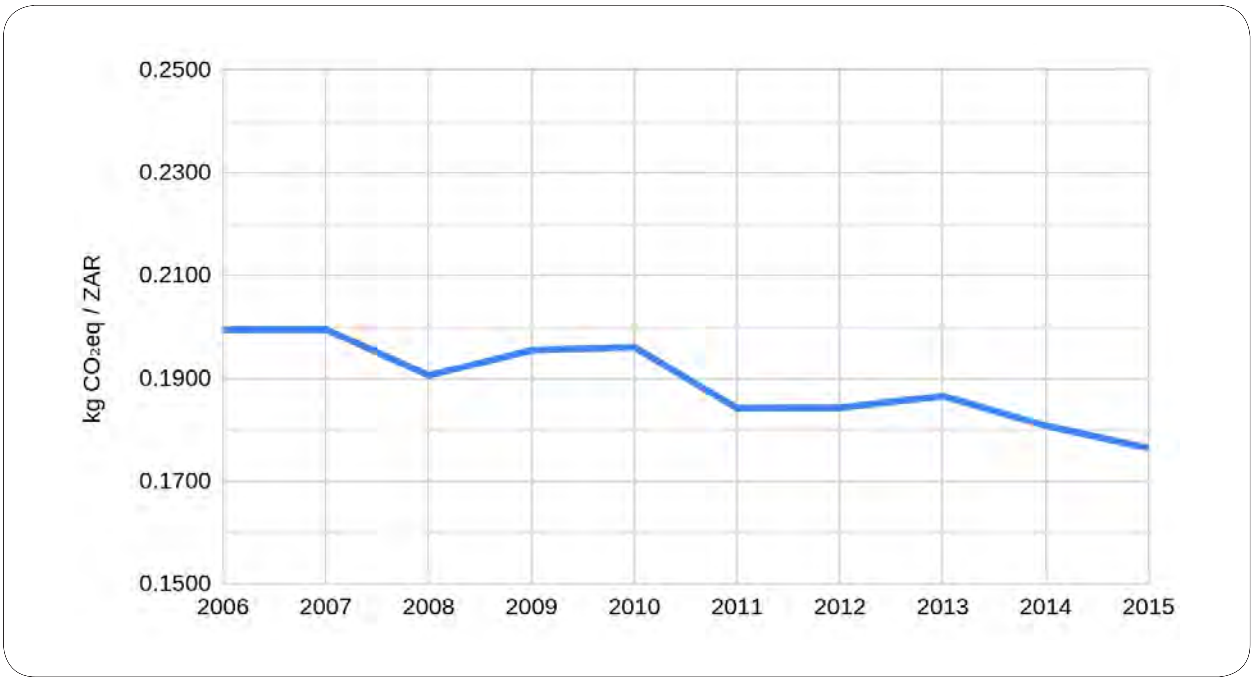

Figure 1.2.1: Carbon intensity of GDP. South Africa's CO_2 emissions per national GDP (at constant 2010 prices).

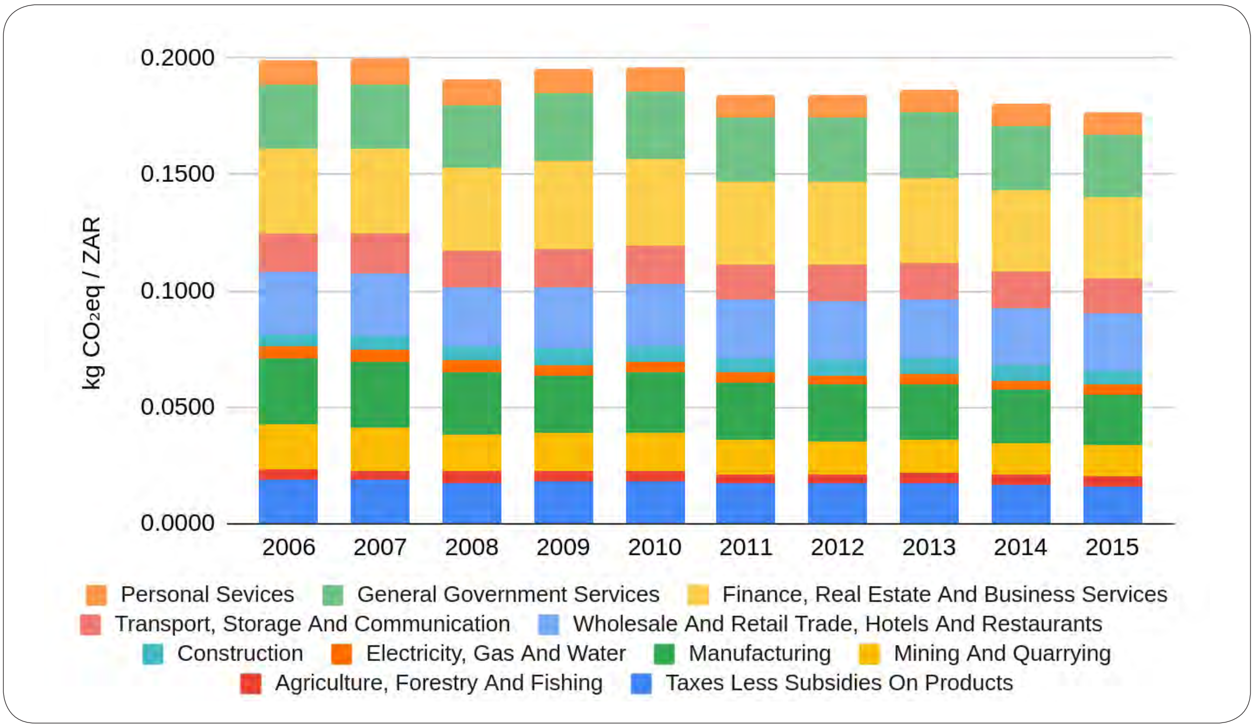

Figure 1.2.2: Carbon intensity of GDP. South Africa's CO_2 emissions per national GDP by industry (at constant 2010 prices).

Analysis

South Africa's 'carbon productivity' (GDP output per unit of GHG emissions) has improved moderately over the past 15 years despite the need to burn diesel and coal in old power stations to prevent power outages. Despite improvements, South Africa remains an incredibly greenhouse gas-intensive economy. World Bank data for 2014 suggest that South Africa produces twice as much CO_2 per $ of GDP (adjusted for purchasing power of parity) than the global average. Despite its high baseline, South Africa's carbon productivity gains since 1990 have been lower (89%) than the global gains (130%). The global trend is driven by developing countries finding ways to grow their economies without emitting GHG and developed countries decarbonising their existing economic activity.

Data

Table 1.2.1: Carbon intensity of GDP. South Africa's CO_2 emissions per national GDP (at constant 2010 prices).

	Carbon intensity of GDP (kg CO_2 equivalent / ZAR GDP)
2006	0.1995
2007	0.1996
2008	0.1906
2009	0.1954
2010	0.1961
2011	0.1842
2012	0.1843
2013	0.1866
2014	0.1808
2015	0.1765

Data notes

Other economic growth datasets include dollar-based GDP, adjusted for purchasing power of parity (see World Bank data https://data.worldbank.org/indicator/EN.ATM.CO2E.PP.GD.KD?locations=ZA-1W-CN-IN- DE-US). The rand-based metric used in this parameter offers a clearer proxy for local progress as it smooths the influence of currency fluctuations, but an indicator adjusted for PPP might be better for international comparisons.

In the GHG National Inventory Report 2017 the Global Warming Potentials (GWPs) from the IPCC Second Assessment Report (SAR) were applied to comply with UNFCCC reporting requirements.

Data sources

Department of Environmental Affairs, (2017). GHG National Inventory Report South Africa 2000-2015. Retrieved from https://www.environment.gov.za/sites/default/files/reports/

Statistics South Africa, (second quarter 2019). Gross Domestic Product (GDP). Retrieved from http://www.statssa.gov.za/publications/P0441/

Indicator status and recommendations for the way forward

Tier 1

INDICATOR 1.3: EMPLOYMENT BALANCE IN THE ELECTRICITY SUPPLY SECTOR

Indicator definition

The change in number of jobs in the coal-fired electricity industry versus the change in number of jobs in the renewable energy industry.

Indicator rationale

The indicator provides a measure of 'just transition' in South Africa's crucial electricity sector. It speaks to deep-seated fears that the shift away from coal (as envisaged in the Integrated Resource Plan of 2019) and the requirement to make electricity cheaper and retain trade competitiveness, will result in mass unemployment. The shift away from coal must create work opportunities in the green economy sector to avoid the heightened risks and deprivation that accompany high levels of unemployment. The indicator is important in informing an ongoing national debate, in bringing organised labour around to the renewable energy sector and in ensuring that the green economy remains labour intensive rather than replicating the prevailing capital-labour structure of South Africa's brown economy.

Data visualisation

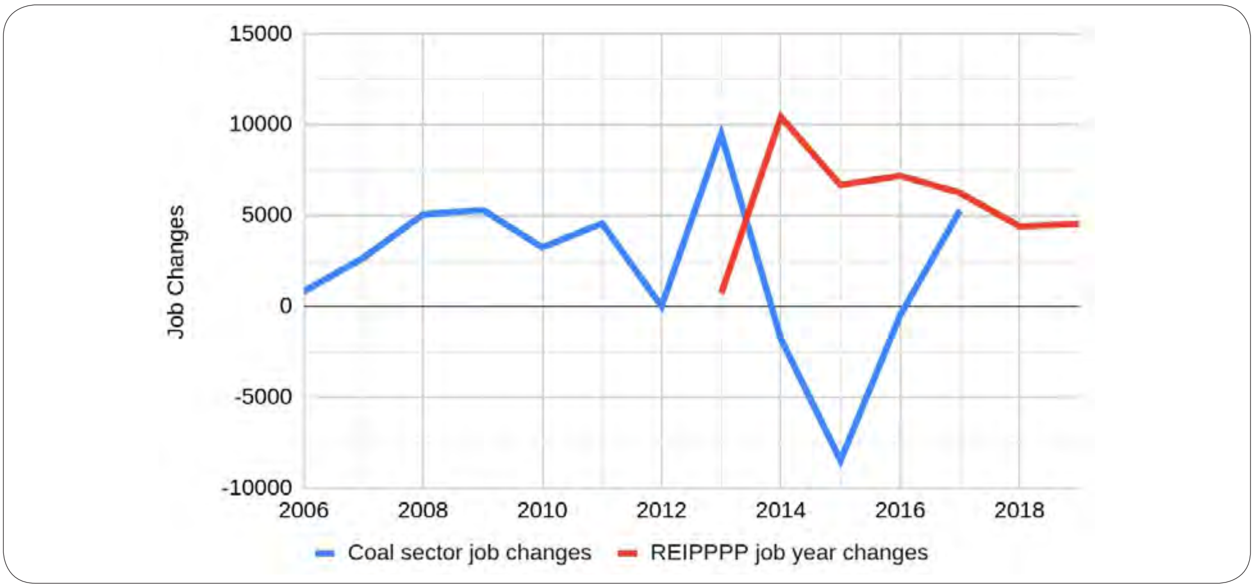

Figure 1.3.1: Employment balance in electricity supply sector. Year-on-year differences in jobs in the South African coal sector and in job years created by the REIPPPP.

Analysis

The critical need is for employment creation in the construction and operations of the renewable energy sector to more than off-set job losses associated with South Africa exiting the coal industry by 2050. Where this is true, these jobs will be more geographically dispersed and less damaging to worker's health and the environment. While the available data are not perfectly commensurate, and do not assist in bringing clarity to the political nature of this critical challenge, they do show the significant employment potential of the renewable energy economy even at its current small size. A lot of the jobs created by the renewable energy sector have been in the construction phase of REIPPPP projects but given that this construction phase could continue for at least the next 20 years, the available data are encouraging. Attention must be given to the geographic location of employment lost and employment created and the need for new skills sets. Together with the data in 1.4, this indicator suggests the renewable energy sector could be a key component of national employment-creation efforts.

As the renewable energy sector expands beyond REIPPPP through company and household cogeneration, employment creation at this level will have to be monitored at a finer scale.

Data

Table 1.3.1: Employment balance in electricity supply sector. Year-on-year differences in jobs in the South African coal sector and job years created by the REIPPPP.

	Coal sector job changes	REIPPPP job year changes
2006	807	
2007	2661	
2008	5045	
2009	5307	
2010	3234	
2011	4555	
2012	-1	
2013	9460	708
2014	-1797	10413
2015	-8495	6664
2016	-488	7180
2017	5268	6242
2018		4400
2019		4527

Data notes

There are no perfectly commensurate data sets for employment creation in the respective energy sub-sectors, which is unfortunate given the importance of energy and job creation in South Africa. A consolidated database would be insightful for informing public policy. To address this problem in the above indicator, the annual change in coal sector jobs has been compared to the annual change in job years reported by the REIPPPP.

Data sources

Department of Mineral Resources, (2018). South Africa Mineral Industry. Retrieved from https://www.gov.za/sites/default/files/

Department of Energy, (2017). State of Renewable Energy in South Africa. Retrieved from http://www.energy.gov.za/files/media/

Indicator status and recommendations for the way forward

Tier 2

The required employment data does not currently exist in the public domain.

Currently showing: Changes in employment in the coal industry versus job year changes in REIPPPP, on an annual basis.

Required: Energy sector specific employment data, in 'job years' or in absolute employment numbers applied to all energy sub-sectors in the same way.

1.4 INDICATOR 1.4: EMPLOYMENT INTENSITY OF ELECTRICITY OPTIONS

Indicator definition

Job years per unit of electricity, compared across different electricity generation options.

Indicator rationale

South Africa's electricity sector should be a source not just of energy, but also of work and employment. Access to safe and affordable electricity is a prerequisite for development. At the same time, the generation of electricity can itself create work and employment. South Africa's Integrated Resource Plan 2019 makes the case for "anticipating impacts on employment". While South Africa's coal emissions must be cut (either by carbon capture and storage or the exiting of coal-fired energy), the IRP is equally clear that this transition must be linked with the protection of employment options and the creation of new employment. Whilst estimates exist, reliable and comparable data on the number of employees per kWh of electricity produced by different feedstocks is hard to come by in South Africa, making it difficult to anticipate risks and opportunities for employment under the IRP. This lack of publicly agreed data persists despite the links between energy and employment being the subject of intense national debate.

Data visualisation

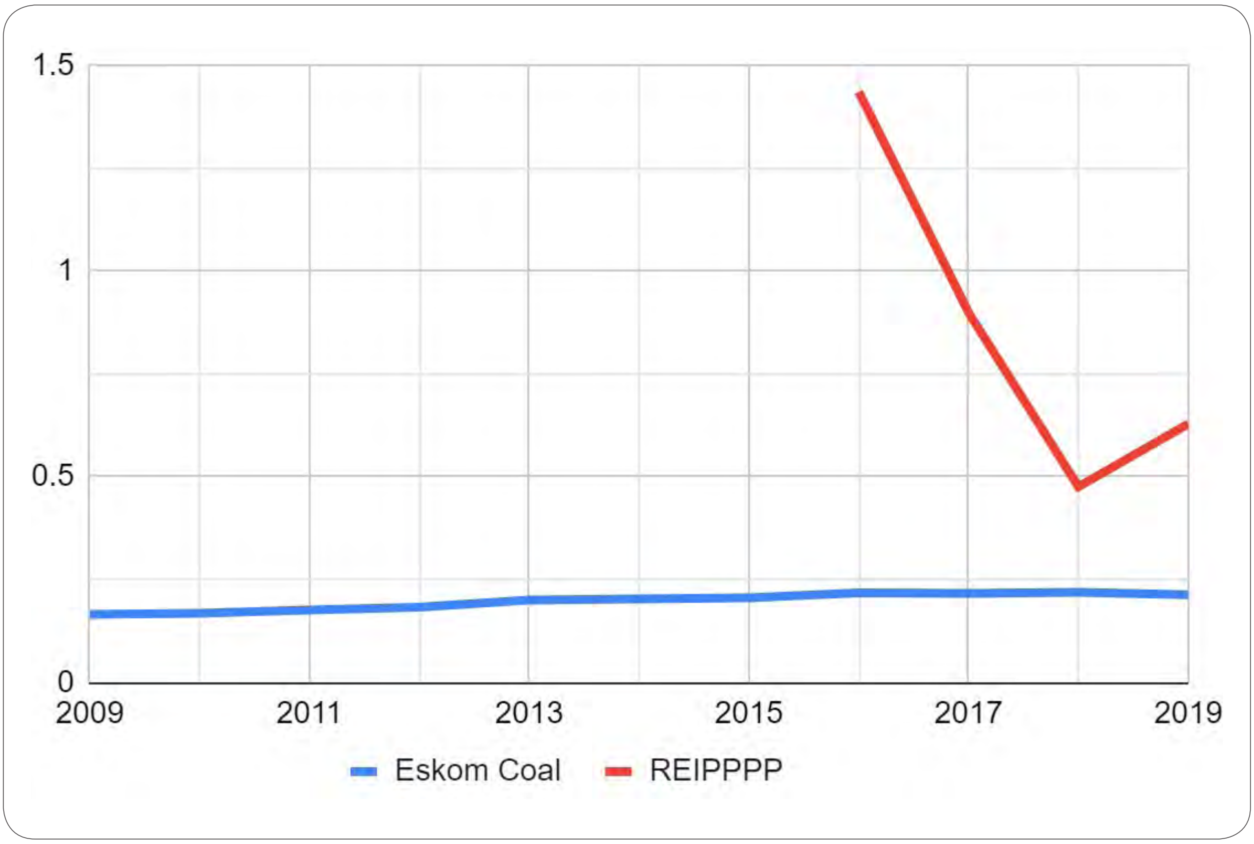

Figure 1.4.1: Employment intensity of energy options. Eskom employment per GWh of Eskom coal generated energy (blue line) vs REIPPPP employment per GWh of REIPPPP generated energy (red line). Eskom's coal employment was calculated using the percentage of coal energy generated (compared to total energy generated) to pro rata employment numbers.

Analysis

It is clear from the data that is available that per kilowatt hour renewable electricity is more labour intensive than coal-fired electricity (even though direct comparisons remain difficult) due to the different value chains associated with the respective electricity options.

Data

Table 1.4.1: Employment intensity of energy options. Eskom employment per GWh of Eskom coal-generated energy and REIPPPP employment per GWh of REIPPPP-generated energy. Eskom's coal employment was calculated using the percentage of coal energy generated (compared to total energy generated) to pro rata employment numbers.

	Eskom Coal	REIPPPP
2009	0.165	
2010	0.168	
2011	0.176	
2012	0.183	
2013	0.200	
2014	0.203	
2015	0.205	
2016	0.218	1.435
2017	0.216	0.898
2018	0.219	0.475
2019	0.213	0.629

Data notes

In an era when South Africa is balancing 'least cost electricity' and the imperative of job creation, it is conspicuous that we do not have more readily available and comparable data on the employment potential of different electricity generation options over their full lifespans. Both coal-fired electricity and the REIPPPP programme operate under a highly regulated market, and this regulation could include submission of annual employment data that would enable a direct comparison.

Note that a job year is the equivalent of a full-time employment opportunity for one person for one year.

Data sources

Independent Power Producers Procurement Programme (IPPPP), (2016-2019) *Overview Reports*. Retrieved from https://www.ipp-projects.co.za/Publications

Eskom, (2008-2019) *Annual Integrated Reports*. Retrieved from http://www.eskom.co.za/IR2016/Documents/

Indicator status and recommendations for the way forward

Tier 2

The required employment data does not currently exist in the public domain.

Currently showing: Employment per GWh of Eskom coal-generated energy (using % coal energy generated to pro rata employment numbers, Eskom employment given as total current jobs at the end of financial year) versus employment per GWh of REIPPPP-generated energy (REIPPPP employment listed as cumulative job years so using yearly change/delta jobs).

Required: Energy sector specific employment data, in job years, and energy generation data for the same energy sectors as for the employment data.

Potential sources: Detailed employment data (reports contain graphs of employment split by construction and operations) from IPP; employment data from Stats SA.

INDICATOR 1.5: GREENHOUSE GAS INTENSITY OF EXPORTS

Indicator definition

Export revenue of South Africa's top export categories against greenhouse gas emissions associated with those categories.

Indicator rationale

Tracking the indicator is important if South Africa is to understand and manage its exposure to decarbonisation and carbon pricing in international trade. This, in turn, is important to South Africa's balance of payments and macro-economic stability. It is therefore important to oversee the transformation of export revenue earning companies and sectors (e.g. Sasol, coal exporters, platinum group metals companies) so they retain export revenue, share price and jobs, but emit less GHGs and remain competitive in the global economy.

Data visualisation

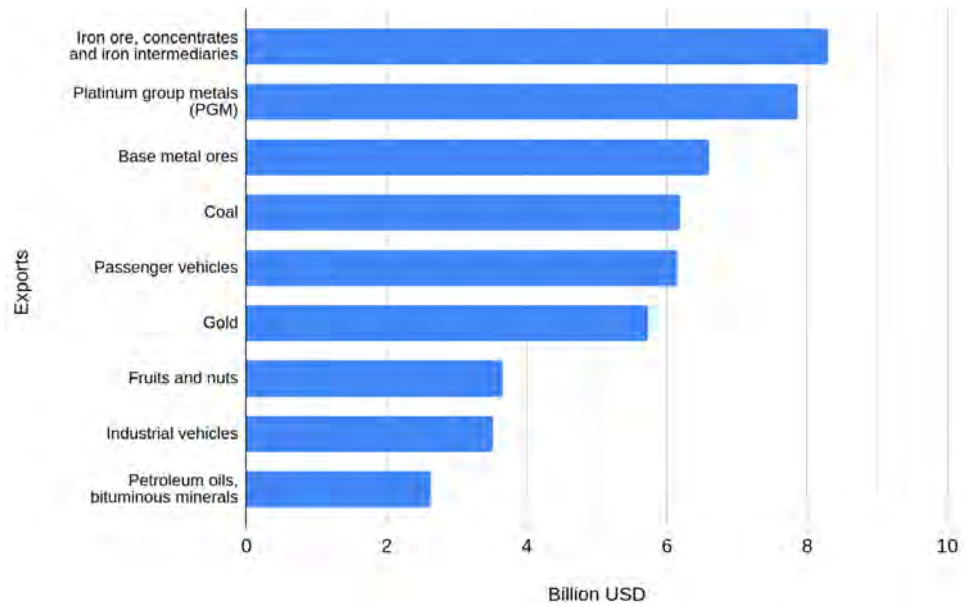

Figure 1.6.1: South Africa's largest, by revenue, exports in 2018.

Analysis

It is not yet possible to attribute emissions to specific export categories as reported by UNCTAD categories in South Africa. Macro-economic models and input-output models do apply sectoral emissions coefficients to specific sectors, but the categorisation of sectors does not align with those reported in trade data. What is self-evident, however, is that South Africa's top export earning sectors are all associated with greenhouse gas emissions. This finding underpins South Africa's transition risk to a stable low-carbon economy.

Data

Table 1.5.1: South Africa's largest, by revenue, exports in 2018. (Source: UNCTADstat 2019)

Product label (SITC Rev3)	Product code (SITC Rev3)	US dollars at current prices in billions
Iron ore and concentrates; Pig iron & spiegeleisen, sponge iron, powder & granu	281; 671	8.295211968
Silver, platinum, other metals of the platinum group	681	7.866661289
Ores and concentrates of base metals, n.e.s.	681	6.595037337
Coal, whether or not pulverized, not agglomerated	321	6.175285831
Motor vehicles for the transport of persons	781	6.148302494
Gold, non-monetary (excluding gold ores and concentrates)	971	5.736537469
Fruits and nuts (excluding oil nuts), fresh or dried	57	3.663258683
Motor vehicles for transport of goods, special purpose	782	3.514469745
Petroleum oils or bituminous minerals > 70% oil	334	2.630789289

Data notes

Export categories as reported by UNCTAD do not yet correspond to the categories under which emissions are reported in South Africa. If South Africa is to manage its export risk in a carbon-constrained world, it needs to reconcile this data.

Data sources

United Nations Conference on Trade and Development Stat (UNCTADstat), 2019. Merchandise: Trade matrix - detailed product exports, annual [Data file]. Retrieved from https://unctadstat.unctad.org/7zip/US_TradeMatrix_E_3Digits.csv.7z

Indicator status and recommendations for the way forward

Tier 2

Required: GHG emission data per export sector (commodity) as reported by UNCTAD. While export revenue data are readily available, this indicator requires GHG reporting under the same categories as the trade data. This does not seem to exist. The critical focus is on South Africa's top five exports: platinum (unwrought); coal, solid fuels made from coal; cars; gold (unwrought); iron ores, concentrates, all of which are generally associated with intense emissions.

Potential sources: South Africa's input-output models (that is the Computer Generated Equilibrium Models and Social Accounting Matrices), used by DTI and National Treasury, contain GHG coefficients for sectors that may be used in populating this indicator, if these models can be accessed (see for example, the University of Pretoria's UPGEM model). Alternatively, the commercial database EcoInvent, for which the South African company The Greenhouse is the local agent, contains data on emissions coefficients for a variety of products. The appendices to South Africa's Carbon Tax Act (15 of 2019) contains Scope 1 emissions for a variety of products, which could be used as an initial indicator in establishing the GHG intensity of exports and imports. In time the development of more complete ISO standards documenting the GHG footprint of South Africa's goods and services will assist in populating this indicator.

1.6 INDICATOR 1.6: COST OF ELECTRICITY

Indicator definition

Compares the cost of various sources of electricity per kWh.

Indicator rationale

Access to cheap, clean, safe electricity is important for development in general and is highly correlated with poverty alleviation. The same electricity would enable South Africa's transition to electric vehicles. There is a need for more reliable (less contested) estimates of electricity costs per electricity sub-sector (or feedstock option) to enter the public discourse in order to support the IRP 2019 goal of 'least-cost electricity supply'.

Data visualisation

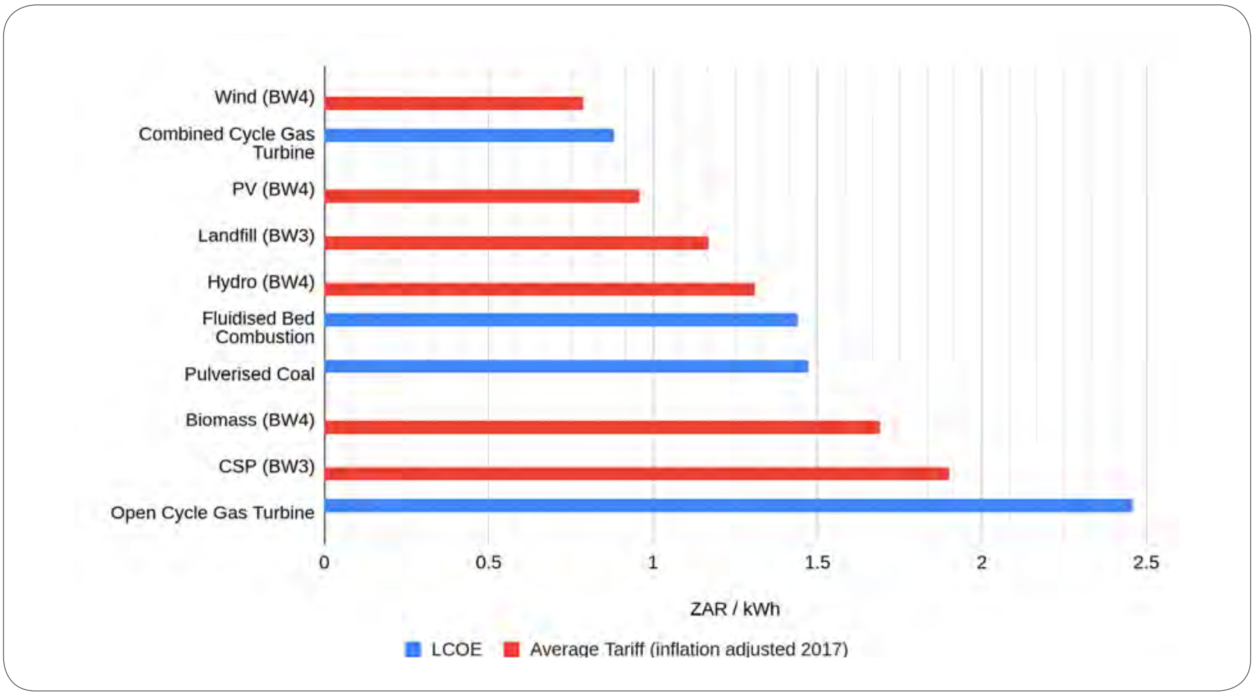

Figure 1.6.1: Cost of electricity by various energy technologies in South Africa (2017). Non- renewable technologies are represented by the levelized cost of electricity (LCOE) values (blue) with renewable technologies represented by the average tariff bid by preferred bidders during the most recent bidding windows of the REIPPPP (red), inflation-adjusted to 2017 prices.

Analysis

The data confirm the global analysis that renewable energy has become cheaper than (or cost-competitive with) thermal energy. What the data do not capture is the externality cost of GHGs or the price trend in the respective technologies. There is also a range of estimates for these technologies, suggesting the analysis is contested. Given the importance of this price indicator for South Africa's pursuit of what the IRP calls 'least-cost electricity' procurement, it might be expected that widely accepted estimates become part of the economic discourse in the near future.

Data

Table 1.6.1: Cost of electricity by various energy technologies in South Africa (2017). Non- renewable technologies are represented by the levelized cost of electricity (LCOE) values with renewable technologies represented by the average tariff bid by preferred bidders during the most recent bidding windows/rounds of the REIPPPP, inflation adjusted to 2017 prices.

	Average Tariff (inflation adjusted 2017) (ZAR/kWh)
Onshore Wind (BW4)	0.79
Solar Photovoltaic (BW4)	0.96
Concentrated Solar Power (BW3)	1.9
Small Hydro (BW4)	1.31
Biomass (BW4)	1.69
Landfill Gas/Waste to Energy (BW3)	1.17
	LCOE (ZAR/kWh)
Pulverised Coal (1x750MW with Flue-gas desulfurization)	1.47
Fluidised Bed Combustion (4x250MW with Flue-gas desulfurization)	1.44
Open Cycle Gas Turbine (132MW)	2.46
Combined Cycle Gas Turbine (732MW without Carbon Capture)	0.88

Data notes

The cost of electricity for renewable energy sub-sectors is represented by the average tariffs bid by preferred bidders during the most recent bidding windows of the REIPPPP, which are inflation adjusted to 2017 prices.

The cost of electricity for non-renewable energies are represented by the levelized cost of electricity (LCOE) values as reported in studies cited by the IRP.

Data sources

Independent Power Producers Procurement Programme (IPPPP), (2018) An Overview. Retrieved from https://www.ipp-projects.co.za/Publications

Department of Energy, 2017. Power Generation Technology Data for Integrated Resource Plan of South Africa, Technical Update. Prepared by: Electric Power Research Institute (EPRI).

Indicator status and recommendations for the way forward

Tier 2

Comment: Comparable costs of electricity (using levelized cost estimates or even 'overnight cost estimates') are central to the pursuit of 'least-cost electricity' and economic competitiveness. While various estimates exist, there is not yet a standard accepted measure of the cost of electricity available to South Africa.

INDICATOR 1.7: INVESTMENT IN CLIMATE ADAPTATION

1.7

Indicator definition

Total amount of money invested in climate adaptation.

Indicator rationale

Even at current levels of warming, South Africa needs to adapt and build resilience to the biophysical, social and institutional impacts of climate change in order to avoid risks and seize new opportunities. Most international studies suggest that it is cheaper to invest in adaptation and resilience than to manage disasters once they strike.

The National Climate Change Response Strategy defines climate finance as "all resources that finance the cost of South Africa's transition to a lower-carbon and climate resilient economy and society. This covers both climate-specific and climate-relevant financial resources, public and private, domestic and international. This includes: financial resources that go towards reducing emissions and enhancing sinks of greenhouse gases; reducing vulnerability, maintaining and increasing the resilience of human and ecological systems to negative climate change impacts; climate-resilient and low-emission strategies, plans and policies; climate research and climate monitoring systems; as well as climate change capacity-building and technology" (DEA, 2011).

While the definition is not perfect, and is not perfectly recorded, DFFE began to collect data on investment of grants and loans from bilateral donors, multilateral donors and the South African fiscus, respectively in 2018.

Data visualisation

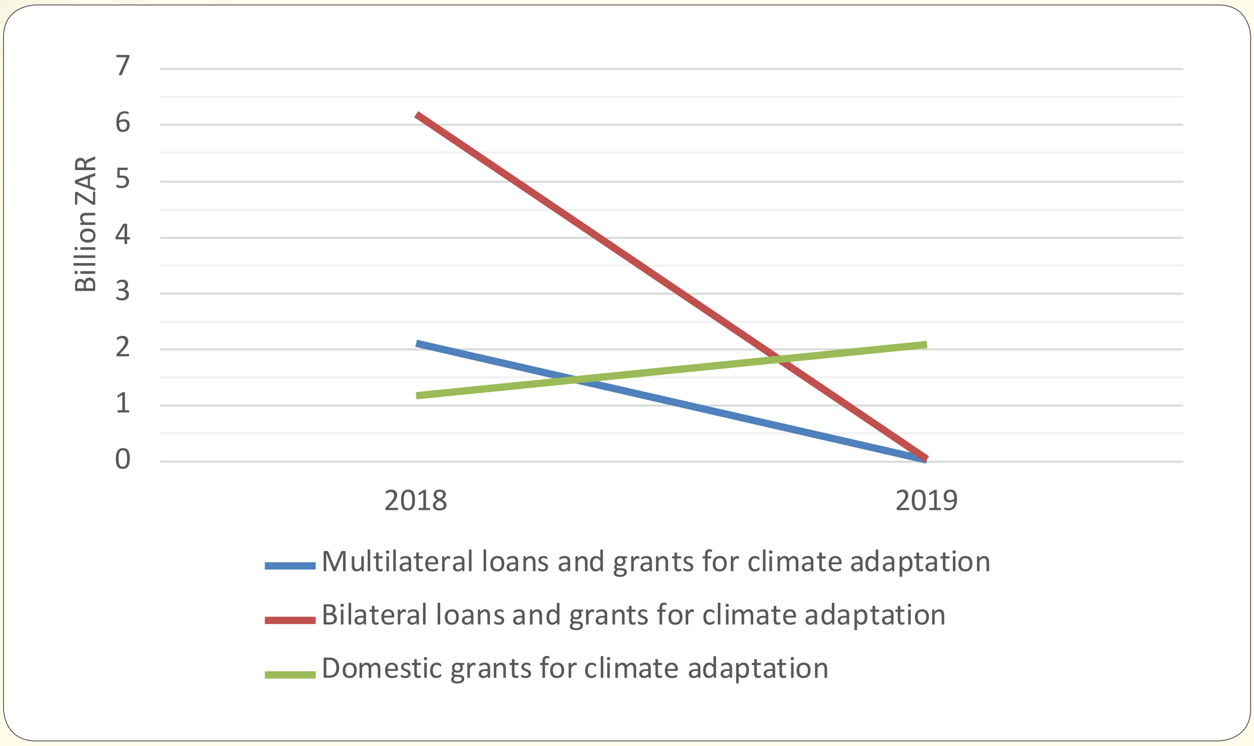

Figure 1.7.1: Total adaptation finance (grants and loans) from bilateral and multilateral sources and grants from domestic sources 2018 and 2019 (based on when money was received).

Analysis

Domestic investment in adaptation increased slightly from 2018 to 2019. The trends for grants and loans from bilateral and multilateral grants and loans is not possible to track from two years, but will emerge over time. A great proportion of the domestic investment came from DFFE in the form of mitigation and capacity building grants.

Data

Table 1.7.1: Data for climate finance and climate adaptation finance (ZAR)

Source of finance	2018	2019
Multilateral loans and grants for climate adaptation	2,111,152,905	34,153,167
Bilateral loans and grants for climate adaptation	6,194,110,004	2,094,002,664
Domestic grants for climate adaptation	1,177,644,704	2,094,002,664

Data notes

DFFE began collecting these data for 2018 and 2019, noting the amount in the year that the agreement is signed and the money is received. The investment of this money across the two years is not currently clear.

The current dataset denotes whether an amount was for mitigation, adaptation or capacity building. The amounts reported for adaptation investment here include the total invested where adaptation is noted as either the exclusive or one of the components of the investment.

The notion of 'additionality' is conceptually useful. In practice it has proven difficult to apply and has been loosely applied to the notion of climate finance in this indicator. Interest payments on loans is not yet recorded as a cost or investment.

Data sources

Department of Environment, Forestry and Fisheries (2020).

Database tracking South Africa's climate finance provided from multilateral, bilateral, and domestic sources as well as financial and non-financial support needs. This early stage database will with time become available on the South Africa's Climate Change Information System: https://ccis.environment.gov.za/

Indicator status and recommendations for the way forward

Tier 2

Required: This is a very difficult parameter to populate due to the tricky distinction between adaptation and mitigation. A clear definition of climate change adaptation that enables classification of budget allocations, as well as access to the relevant budgets, is needed. In time private investment in adaptation might be added to this indicator, as might interest payments on climate finance loans.

The quantum of adaptation money received from donors and Direct Foreign Investments (DFIs) needs to be recorded based on when it is spent, not when it is received which tends to load the amounts up-front. Presumably some of the money received in 2018 was spent in 2019.

A clear position on how additionality is to be applied is also necessary.

Comment: Work has begun within DFFE to populate this important indicator, in line with UNFCCC requirements. This has forced South Africa to develop a definition of adaptation finance which is positive. DFFE is working with COGTA to make sure local governments account accurately on climate finance.

1.8

INDICATOR 1.8: RENEWABLE ENERGY INDEPENDENT POWER PRODUCER PROCUREMENT PROJECTS COMMUNITY IMPACT

Indicator definition

Payments made to community trusts by all Renewable Energy Independent Power Producer Procurement Projects (REIPPPP).

Indicator rationale

Community benefit was a design requirement of REIPPPP and was included to ensure that this new energy sub-sector delivered more wide-spread benefits than the sub-sectors it was replacing. Actual payments to community partners are estimated to be very high but need to be monitored carefully to hold project developers and trustees accountable for their commitments. The REIPPPP was designed to include local economic benefits. Monitoring the resources generated by the REIPPPP is important oversight and a crucial part of understanding some of the co-benefits associated with South Africa's renewable energy programme.

Data visualisation

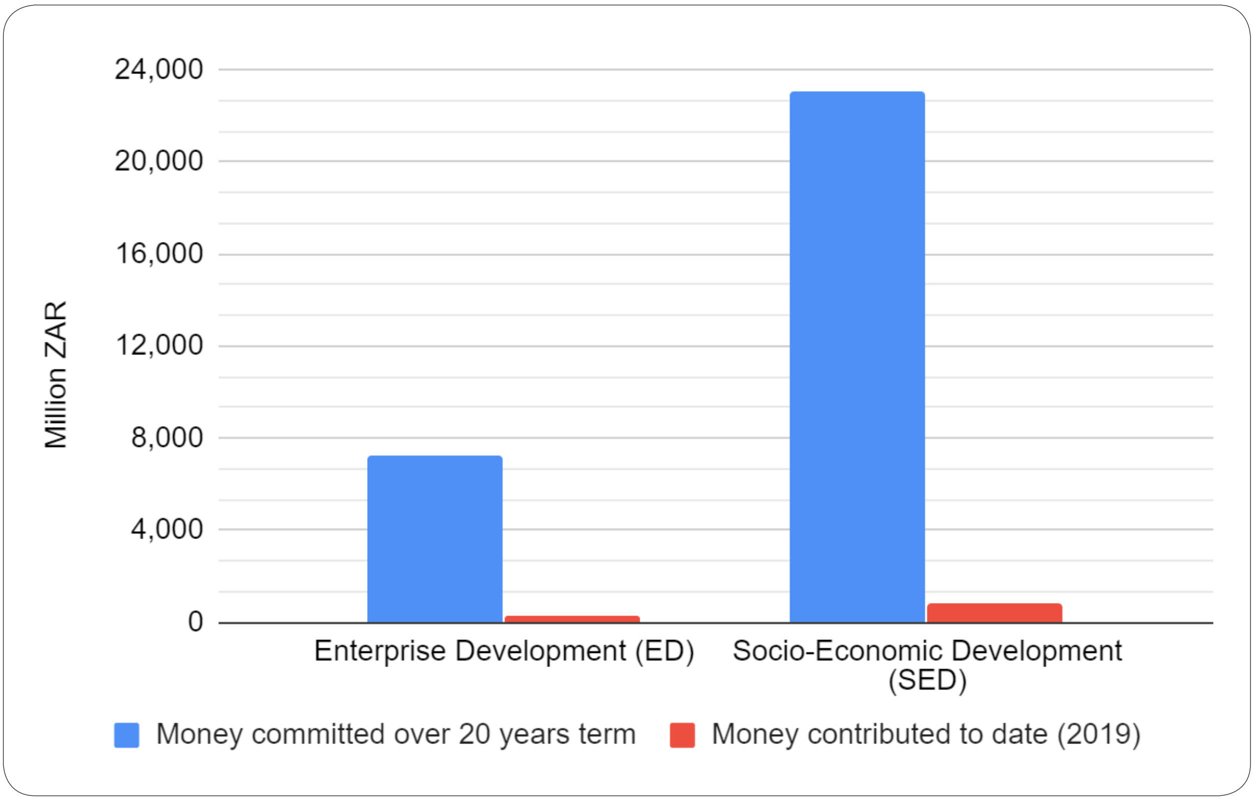

Figure 1.8.1: REIPPPP community impact. Money committed by the REIPPPPs over the 20- year project term (blue) and money paid (red) from inception to date (2019) towards enterprise and socio-economic development.

Analysis

The money paid out to communities for enterprise development and socio-economic development currently stands at 3.84% and 3.72%, respectively, of what was pledged on the signing of contracts. This low number is understandable given that projects have been paying back capital in their initial phases but commitment to pledges should be monitored closely over the next decade as payments become due. A secondary analysis, once it has been established that due money has been paid out, should focus on the development outcomes of this transfer, but that is not the focus of this indicator.

Data

Table 1.8.1: Money committed by the REIPPPPs over the 20-year project term and money paid from each project inception to date (2019) towards enterprise and socio-economic development.

	Money committed	Money realised	Percentage
Enterprise Development (ED)	R7,200,000,000	R276,700,000	3.84%
Socio-Economic Development (SED)	R23,100,000,000	R860,100,000	3.72%

Data notes

More detailed data around the actual payments from individual projects to community partners would provide more insight.

Data sources

Independent Power Producer Office, 2019. Independent Power Producers Procurement Programme (IPPPP): An Overview. Retrieved from https://www.ipp- projects.co.za/Publications

Indicator status and recommendations for the way forward

Tier 2

Required: More detailed REIPPPP projects data.

Comment: It is recognised that money paid to projects does not necessarily equate to positive impact.

ANALYSIS AND REFLECTION ON INDICATORS IN THE ECONOMIC STRUCTURE, WORK CREATION AND ECONOMIC GROWTH NARRATIVE

Understanding the economic origins of GHGs and the economic impact of climate change is crucial to an effective climate response in South Africa. South Africa's GHG intensity and 'transition risk' is a function of the economic structure and coal-fired electricity supply on which the country has become dependent over the past century. It is the same economic structure that makes employment creation, poverty alleviation and economic growth difficult, which in turn creates the scope for synergistic solutions.

A just climate transition will be required to create more work and economic opportunity while reducing emissions and ensuring climate resilience. This is only likely if this transition simultaneously tackles the problematic elements of South Africa's economic structure – most obviously: the concentration of economic influence in the hands of a few large corporates, low levels of investment in skills development, dependency on coal-fired electricity from a national monopoly-monopsony, reliance on carbon-intensive exports for the country's macro-economic stability, spatially-defined access to economic opportunity giving rise to a disconnect between where poor people live and where economic opportunities are being created and a gender gap in labour market participation and wages. Unless the transition to a low-carbon, climate-resilient economy simultaneously tackles these structural features it is unlikely to generate the social compacts necessary to succeed.

South Africa has made modest progress increasing the number of people employed per unit of GHG emissions (Indicator 1.1) and in 'carbon productivity' – the GDP that is produced per unit of GHG emissions (Indicator 1.2). In both instances, however, South Africa performs significantly worse than the global average, and the rate of decarbonisation of GDP over the past three decades has been slower than the global rate.

Jobs and access to decent work is a social imperative and political priority in South Africa, and the pace and scale of the economic transition that is necessitated by climate change in South Africa could pose a risk to jobs unless managed proactively. Indicator 1.3 suggests that the renewable energy sector is already making up for the shortfall in coal-fired electricity jobs resulting from the shift away from coal. While the data are not yet perfectly commensurate, there appears to be considerable employment creation in the construction and operating of renewable energy (Indicator 1.4).

Crucially, despite many of these issues featuring in policy debates, South Africa appears not to have the readily available and widely accepted data with which to gauge progress on a number of these issues. Most acute in this regard, are data on the employment intensity of different electricity generation options (Indicator 1.4), accepted levelized cost per kilowatt hour of different electricity types (Indicator 1.6) and the emissions that result from our major contributors of export revenue (1.5).

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THEMATIC AREA

NARRATIVE 2

THE ENERGY TRANSITION

Contents

Figures and Tables

NARRATIVE 2 - THE ENERGY TRANSITION

INTRODUCTION TO THE ENERGY TRANSITION NARRATIVE

The usually cautious International Energy Agency is clear in its latest World Energy Outlook (IEA, 2019) that the world is in the early stages of an energy transition with several key developments:

- a shift from fossil fuel based energy sources to renewable energy technologies and storage technologies such as batteries. In South Africa this may also include diversification to lower-carbon fuels such as natural gas;
- electrification of large parts of our energy systems which until now have used fossil fuels (especially significant for transport / electric vehicles);
- decentralisation, meaning that energy systems will generate and store energy locally as well as centrally, which will in turn require a much more sophisticated electricity grid;
- digitisation – the internet and big data will play a critical role in energy systems compared to the past and will facilitate a far larger degree of flexibility and complexity in the management of energy systems.

These developments are being driven by two factors. Firstly, by climate policy internationally, which provides an urgent imperative to reduce greenhouse gas (GHG) emissions from fossil fuel combustion, and thus accelerate a technological revolution in the energy and transport sectors. Secondly, by the resulting rapid drop in the cost of renewable energy technologies, and associated technologies such as batteries and electric vehicles. While climate policy remains a critical driver for the energy transition, the changing economics of low-carbon technologies means that much of this shift will now be driven solely by the market.

In South Africa, this will have a profound effect on the current coal-dominated energy system, with an additional dependence on imported crude oil. While there is a strong motivation to curtail coal and liquid fuels use on climate change grounds, the increasing cost-competitiveness of renewable energy and electric vehicle options provides economic incentives for this transition pathway. Renewable energy technologies are already cheaper than coal for electricity generation (for new plants), and it will become increasingly expensive to either invest in new coal plants, or even to keep old plants running. Soon, electric vehicles at all scales (including scooters, cars and buses) will become significantly cheaper as a transport option compared to existing internal combustion engine vehicles. Electric vehicles will thus gain market share, as a result of favourable economics and climate policy. This will also lead to employment changes, such as job losses in the oil and coal sectors and an increasing number of jobs available in the renewable energy sector. There will also be co-benefits in terms of air pollution, water use and possibly also increased access to safe and affordable transport, with appropriate additional policies in place.

Global technology shifts will result in these changes happening in South Africa regardless of policy. An accelerated and carefully planned transition will have very significant advantages for the country (for example, if workers in the coal industry are reskilled to take up employment opportunities in these new sectors), whereas an unplanned shift may have negative consequences such as unemployment and stranded assets.

At the same time, South Africa's long-term climate change mitigation goal (the 'peak, plateau and decline' emissions trajectory range contained in the National Climate Change Response White Paper) implies a transition away from coal. It is likely that South Africa will come under international pressure to increase its mitigation ambitions in the 2020s, as all countries will have to meet the global temperature goals of the Paris Agreement contained in its Article 2. The shift from a coal-based to a renewables-based energy system, and from a primarily liquid fuels-based transport system to one based on electricity, will have a potentially very disruptive effect. Jobs in coal mining will gradually be lost as mines close and are not replaced by new mines. These losses will primarily be in a specific area of the country (mainly Mpumalanga). On the other hand, new jobs will be created elsewhere, spread more evenly across the country, where new renewable energy projects are built. In addition, industrialisation policies linked to renewable energy technologies could create new jobs. South Africa's current motor industry could shift to manufacturing electric vehicles. Petrol stations could become charging stations. The nature of the transition depends on additional policies being put in place. Without a 'just transition' the shift away from coal could be very disruptive with significant impacts on poor communities, who will not necessarily benefit from the new energy economy.

The transition away from coal and liquid fuels will have additional impacts such as reducing air pollution in some of the worst affected areas, lower water use and changing land-use patterns linking to elements of adaptation for climate change. Broader economy-wide impacts will include changes in investment patterns and in South Africa's trade balance (less crude oil imports and less coal exports). At the same time, in South Africa's developmental context, more traditional energy policy goals must still be met, such as household access to clean energy and energy security.

It is thus necessary to track three elements of this transition. First, the transition itself – the extent to which investment is shifting to low-carbon technologies and away from fossil fuels. This is shown in both national emissions and the sources of energy which the country makes use of, indicating the transformation of energy markets and the progress of specific policy interventions. Second, the costs and benefits of both the current energy system and of the transition, including air pollution, employment, water use and other costs and benefits. And third, the extent to which the important social goals of energy policy, particularly the provision of safe, affordable and clean energy services, are being met.

INDICATOR 2.1: TOTAL GREENHOUSE GAS EMISSIONS PER SECTOR

Indicator definition

The total greenhouse gas emissions per sector.

Indicator rationale

Tracking GHG emissions trends by sector sheds light on the main source of emissions and the effectiveness of decarbonisation policies. This indicator will also track progress against South Africa's Nationally Determined Contributions (NDC) to the Paris Agreement.

Data visualisation

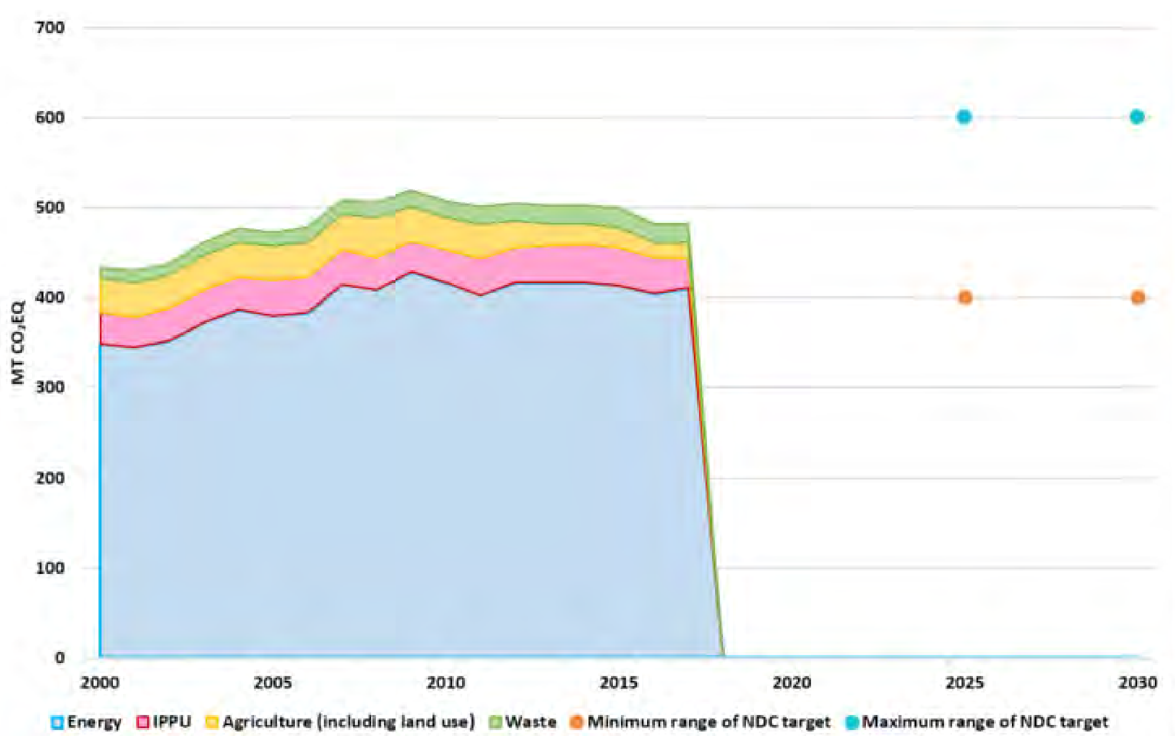

Figure 2.1.1: South Africa's GHG emissions by sector for 2000 to 2017 (calculated with the IPCC Second Assessment Report Global Warming Potentials relative to carbon dioxide) and the upper and lower ends of the country's 2025 and 2030 NDC target range.

Analysis

South Africa's GHG emissions, including land use emissions, grew rapidly until 2007 and have since remained stable until 2017. This is due to a combination of low economic growth rates, a structural change in the economy (lower electricity intensity) and investment in energy efficiency due to rising electricity prices, which indicates that electricity demand has not grown over the last decade.

Data notes

This data is extracted directly from the GHG National Inventory Report South Africa 2000-2017. Numbers have been rounded to the nearest whole number.

Data

Table 2.1.1: Trend in GHG emissions (Mt CO_2eq) by sector for 2000 to 2017 calculated with the IPCC Second Assessment Report Global Warming Potentials relative to carbon dioxide.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Energy	349	345	352	373	387	380	383	415	409	429	417	403	417	417	417	414	404	411
Industrial processes and product use	34	34	36	36	36	39	40	38	36	34	36	40	39	41	42	42	40,0	32,1
Agriculture, forestry and other land use (including land use)	39	38	37	38	39	39	39	40	44	38	36	39	30	24	23	23	16	18
Waste	12	13	13	14	15	15	16	16	17	18	18	19	19	20	21	21	21	21
Total	**434**	**430**	**438**	**461**	**477**	**473**	**478**	**509**	**506**	**519**	**507**	**501**	**505**	**502**	**503**	**500**	**481**	**482**

Table 2.1.2: Trend in GHG emissions (Mt CO_2eq) by sector for 2000 to 2017, supplementary data showing the emissions for the category 'Agriculture, forestry and other land use, excluding data for land use'. This shows the difference between 'Agriculture, forestry and other land use (including land use)' in Table 2.1.1. and net emissions for this category if land use is not included.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Agriculture, forestry and other land use (excluding land use)	52	52	53	51	51	50	50	50	51	49	51	51	50	52	52	51	48	48

Data sources

Department of Environmental Affairs (2020). GHG National Inventory Report South Africa 2000-2017. Department of Environmental Affairs. Pretoria, South Africa.

Indicator status and recommendations for the way forward

Tier I

2.2 INDICATOR 2.2: GREENHOUSE GAS EMISSIONS PER CAPITA

Indicator definition

The total GHG emissions per capita, based on the total South African population.

Indicator rationale

GHG emissions per capita is a key benchmark for assessing the comparative emissions levels of different countries, considering differences between countries in national circumstances, history and level of development. South Africa's GHG emissions per capita are high for a developing country due to the dependence on coal. With more effort to diversify and shift away from coal in the electricity sector, GHG emissions per capita are likely to drop in the future if current policies are implemented.

Data visualisation

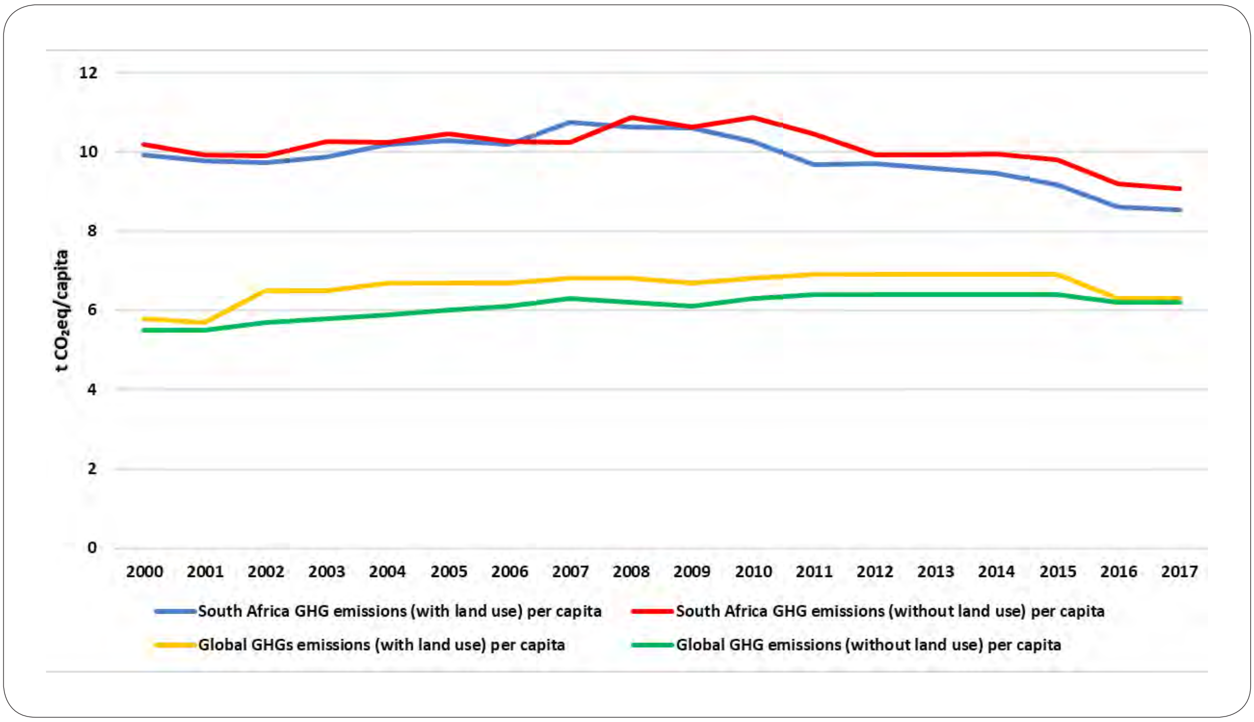

Figure 2.2.1: National and global net (including FOLU) and gross (excluding FOLU) GHG emissions in tonnes of carbon dioxide equivalent (t CO_2eq) per capita, 2002 to 2015.

Analysis

South Africa's GHG emissions per capita have not changed significantly since 2004. Although population growth is not a major driver of GHG emissions in South Africa, GHG emissions growth has kept pace with population growth. For the past few years to 2017, South Africa's GHG emissions dropped slightly, while global GHG emissions remained stable. Since GHG emissions are not likely to grow much further, GHG emissions per capita will slowly begin to decline.

Data

Table 2.2.1: National and global net (including FOLU) and gross (excluding FOLU) greenhouse gas emissions in tonnes of carbon dioxide equivalent (t CO_2eq) per capita, 2002 to 2017.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
South Africa GHG emissions (with land use) per capita	9,93	9,77	9,73	9,87	10,18	10,28	10,18	10,75	10,63	10,59	10,25	9,69	9,71	9,58	9,47	9,17	8,55	8,45
South Africa GHG emissions (without land use) per capita	10,20	9,91	9,9	10,27	10,24	10,46	10,27	10,24	10,87	10,63	10,87	10,46	9,91	9,92	9,94	9,79	9,20	9,07
Global GHGs emissions (with land use) per capita	5,8	5,7	6,5	6,5	6,7	6,7	6,7	6,8	6,8	6,7	6,8	6,9	6,9	6,9	6,9	6,9	6,3	6,3
Global GHG emissions (without land use) per capita	5,5	5,5	5,7	5,8	5,9	6	6,1	6,3	6,2	6,1	6,3	6,4	6,4	6,4	6,4	6,4	6,2	6,2

Table 2.2.2: National net (including FOLU) and gross (excluding FOLU) GHG emissions (Gg CO_2eq), 2002 to 2017, and national population estimates (provides the underlying calculation linking the final table graphed to the data in the National GHG Inventory and Statistics South Africa data).

	National population estimates	National emissions (including land use) in Gg CO_2eq	National emissions (excluding land use)
2000	44 000 000	436 733 490,9	448 874,2397
2001	44 910 000	438 848 073,8	445 277,9286
2002	455 330	443 108 230,1	454 992,5573
2003	46 116 000	455 301 945,6	473 488,9896
2004	46 665 000	474 931 132,9	488 144,51
2005	47 198 000	485 400 601,1	484 911,4505
2006	47 731 000	485 942 045,8	488 884,2319
2007	48 257 000	518 720 956	524 645,6371
2008	48 793 000	518 465 779	518 453,3784
2009	49 320 000	522 296 342,4	535 887,553
2010	49 870 000	511 202 832,2	521 839,1507
2011	51 771 000	501 602 758,7	512 928,2327
2012	52 982 000	514 400 323,3	525 788,3193
2013	53 192 000	509 388 122,5	528 816,206
2014	54 001 953	511 236 874,7	528 548,1248
2015	54 956 920	504 157 851,9	527 301,0095
2016	55 908 865	481 464 301	514 498,7653
2017	56 521 948	482 016 332,9	512 660,6482

Data notes

Data for South Africa is extracted directly from the GHG National Inventory Report: South Africa 2000-2017 and all assumptions are described within this report.

The World Resources Institute CAIT Country GHG global emissions data estimates differ from the sum of the national inventories reported by national governments to the UNFCCC for the reason that the GWP used in country inventories differ, some Annex II countries use global potential warming (GWP) values from IPCC Third Assessment Report or IPCC Second Assessment Report. Annex I countries in 2015 start to use global potential warming (GWP) values from IPCC Fourth Assessment Report, which might result in additional differences in our estimates and those provided by national governments.

Numbers have been rounded to the first decimal point.

Data sources

Department of Environmental Affairs (2018). South Africa's Greenhouse Gas Inventory Report 2000-2017. Department of Environmental Affairs. Pretoria, South Africa. Retrieved from https://www.environment.gov.za/sites/default/files/reports/GHG-National-Inventory-Report- SouthAfrica-2000-2015.pdf

Statistics South Africa, (2019). Mid-year population estimates. Statistics South Africa. Pretoria, South Africa. Retrieved from http://www.statssa.gov.za/?page_id=1866&PPN=P0302&SCH=7668

Climate Watch, Global GHGs per capita. Retrieved from http://cait.wri.org/

Indicator status and recommendations for the way forward

Tier 1

2.3 INDICATOR 2.3: ENERGY-RELATED GREENHOUSE GAS EMISSIONS

Indicator definition

The change in GHG emissions from fuel combustion sectors.

Indicator rationale

The largest driver of national GHG emissions is carbon dioxide emissions from fuel combustion, primarily for electricity production and fuel supply. This indicator tracks the effectiveness of efforts from various sectors to decarbonise the economy.

Data visualisation

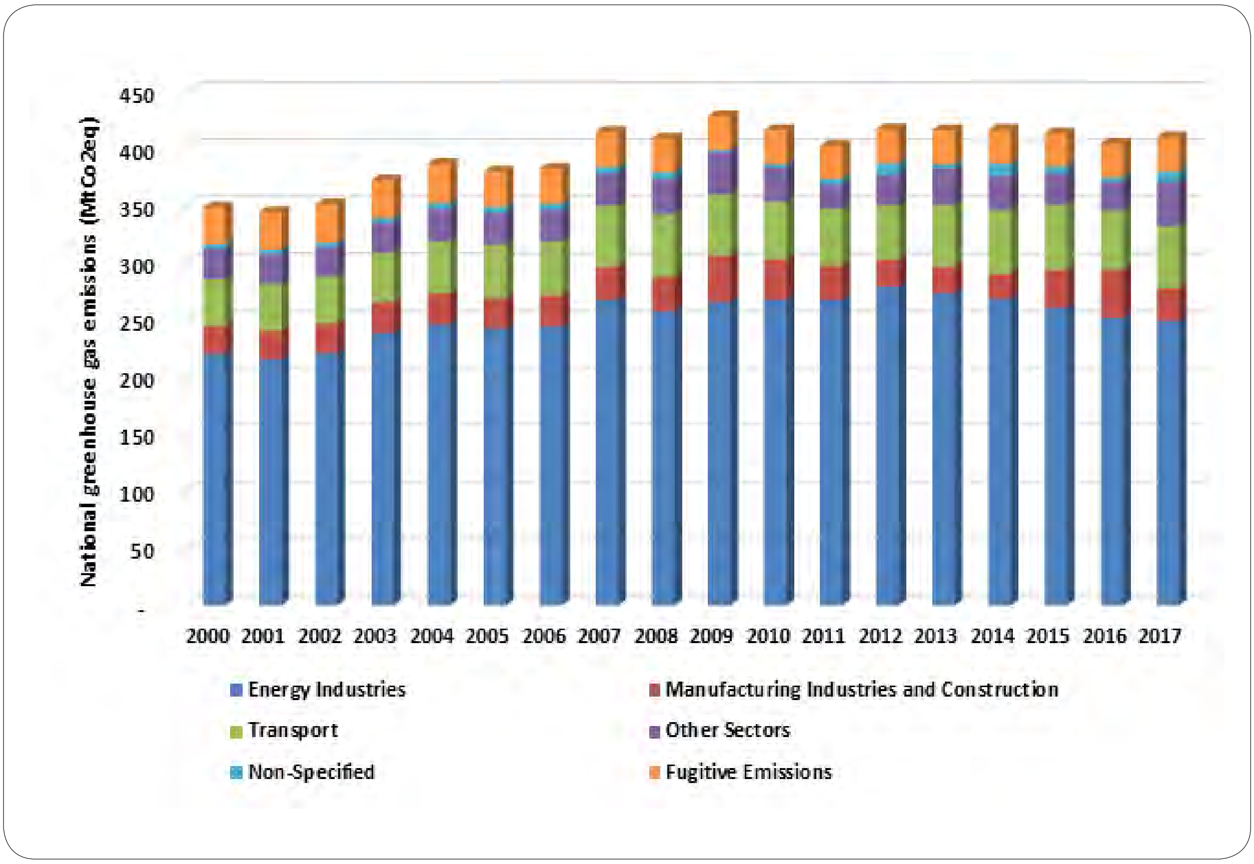

Figure 2.3.1: Energy-related greenhouse gas emissions by sector.

Analysis

Emissions from fuel combustion for electricity production and fuel supply accounts for **60.7%** of energy - related GHG emissions. Total energy-related emissions were slightly lower in 2015 than in 2010, which is attributed to the slowdown in economic growth and declining electricity supply, despite significant growth in transport emissions at **13.3%**. Energy sector emissions increased by 18% between 2000 and 2017 (Table 2.1.1). This growth in emissions is mainly from the 20% increase in fuel combustion activities. There was an increase of 11 899 Gg CO_2e increase in the other sector emissions, a 28 747 Gg CO_2e increase in energy industry emissions and a 13 632 Gg CO_2e increase in transport emissions.

Data notes

Energy-related emissions include fuel processing and fugitive emissions.

Numbers have been rounded to the nearest whole number.

Data

Table 2.3.1: Energy-related greenhouse gas emissions by sector (Mt CO_2eq).

Sectors	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified	Fugitive Emissions	Total Emissions
2000	220 587	24 413	41 063	26 123	4 257	32 656,0716	349 100
2001	215 884	24 776	41 483	25 744	3 980	32 918,9758	344 786
2002	221 177	25 646	41 733	25 504	3 921	33 689,0741	351 671
2003	238 890	26 796	43 254	26 538	4 498	32 624,4612	372 599
2004	246 680	27 003	45 275	28 263	5 611	34 357,9219	387 190
2005	242 786	26 208	47 500	27 529	5 757	30 413,1479	380 194
2006	244 834	26 838	47 448	27 655	5 587	30 267,2467	382 630
2007	268 012	28 274	54 330	28 343	5 570	30 748,1238	415 277
2008	257 213	30 804	55 155	30 408	6 280	29 364,6198	409 225
2009	266 016	40 623	53 452	37 381	1 545	30 071,7055	429 089
2010	267 845	35 984	50 162	29 774	3 517	29 445,6839	416 729
2011	267 890	29 759	50 529	20 759	5 217	28 736,173	402 890
2012	279 356	23 804	47 570	26 435	10 773	29 548,4497	417 487
2013	273 764	23 036	54 366	31 309	4 180	29 982,8241	416 639
2014	268 802	22 017	56 070	29 523	10 946	29 599,1153	416 957
2015	261 128	32 843	57 370	27 808	5 782	29 042,2855	413 973
2016	252 176	42 211	52 195	25 174	3 785	29 211,7829	404 754
2017	249 334	28 766	54 695	38 022	9 726	30 143,1477	410 685

Data sources

Department of Environmental Affairs (2018). GHG National Inventory Report South Africa 2000-2017. Department of Environmental Affairs. Pretoria, South Africa. Retrieved from https://www.environment.gov.za/sites/default/files/reports/GHG-National-Inventory-Report- SouthAfrica-2000-2015.pdf

Indicator status and recommendations for the way forward

Tier I

INDICATOR 2.4: SOUTH AFRICA'S OVERALL PRIMARY ENERGY MIX

Indicator definition

The contribution of each energy source to South Africa's primary energy supply.

Indicator rationale

The composition and level of South Africa's primary energy supply largely determines the country's GHG emissions. As the economy decarbonises, the energy supply is expected to shift from primarily coal to renewable energy. To track this progress requires understanding the share of each energy source to the total energy supply.

Data visualisation

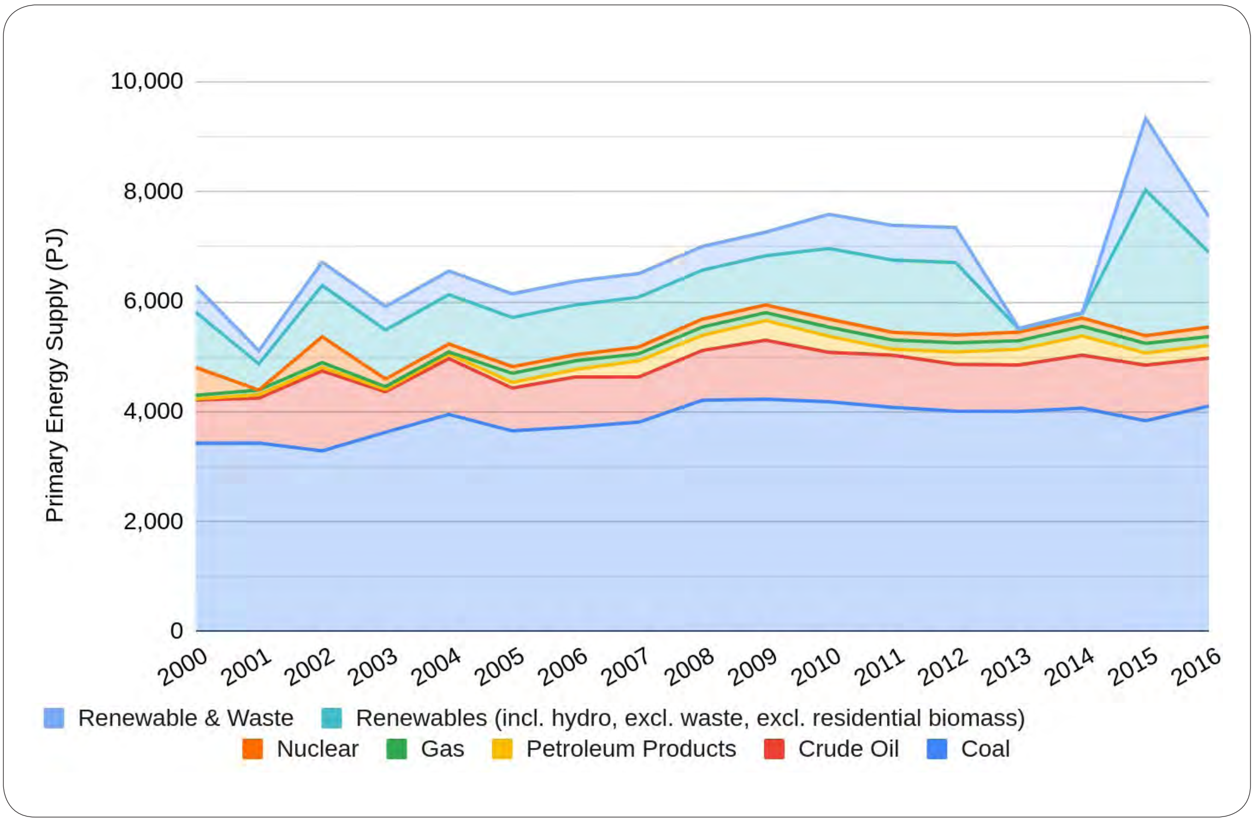

Figure 2.4.1: Share of total primary energy supply by source.

Analysis

Fossil fuels (oil, coal and gas) made up 76% of South Africa's energy mix in 2016. Total primary energy supply has increased to 20% since 2000 most of this growth is from a 25% increase in fossil fuel energy supply. Energy supply from renewable sources increased to 9.5% although the data on renewable energy supply in the national energy balances is not considered to be reliable at present. Primary energy from fossil fuels include conversion losses whereas primary energy from renewable energy sources does not; hence a shift to renewable energy will also entail a drop in total primary energy consumption.

Data notes

Inconsistencies in the Energy Balance data across years are unexplained (for example in Renewables & Waste in 2013 and 2014).

Numbers have been rounded to the nearest whole number.

Data

Table 2.4.1: Share of primary energy supply by source (PJ).

Energy Sources	Coal	Crude oil	Petroleum products	Gas	Nuclear	Renewables*	Renewable & waste
2000	3 426	786	20	65	511	1 006	475
2001	3 433	813	65	84	0	475	237
2002	3 289	1 454	68	84	471	932	424
2003	3 628	737	41	50	138	892	428
2004	3 953	1 015	83	38	146	898	428
2005	3 652	780	103	164	123	895	428
2006	3 721	912	135	160	109	907	428
2007	3 812	820	295	127	123	907	428
2008	4 209	905	277	151	142	894	428
2009	4 227	1 074	359	142	140	895	428
2010	4 180	900	293	164	148	1 282	624
2011	4 081	949	110	166	141	1 313	632
2012	4 010	852	226	166	141	1 316	640
2013	4 007	844	285	156	156	57	13
2014	4 065	963	350	175	150	87	13
2015	3 838	1 010	221	176	138	2 652	1 303
2016	4 103	872	233	159	174	1 356	651

* Renewables includes hydroelectricity and excludes pumped storage and waste and residential biomass.

Data sources

Department of Environmental Affairs (2018). South Africa's Greenhouse Gas Inventory Report 2000-2015. Department of Environmental Affairs. Pretoria, South Africa. Retrieved from https://www.environment.gov.za/sites/default/files/reports/GHG-National-Inventory-Report- SouthAfrica-2000-2015.pdf

Department of Energy, (no date) Consolidated Aggregated Historical Energy Balances per commodity. Microsoft Excel File. Retrieved from http://www.energy.gov.za/files/energyStats_frame.html

Indicator status and recommendations for the way forward

Tier I

2.5 INDICATOR 2.5: CARBON INTENSITY OF THE ENERGY SECTOR

Indicator definition

The change in carbon intensity of the national energy supply.

Indicator rationale

Tracking the measure of carbon intensity for energy supply reveals the rate of transition to a Lower-carbon economy. Around 80% of South Africa's GHG emissions are related to energy production and/or use, therefore this is a key indicator to track progress on the decarbonisation of the national energy supply. South Africa's energy supply is particularly emissions-intensive due to the high dependence on coal use.

Data visualisation

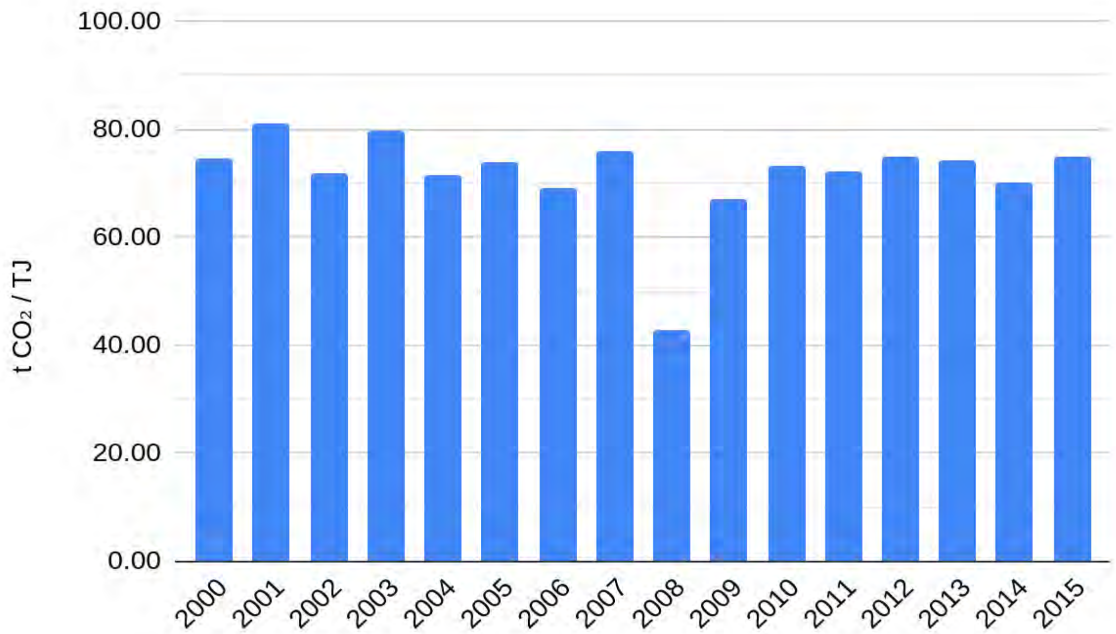

Figure 2.5.1: GHG emissions per unit of total primary energy supply.

Analysis

Energy is a fundamental input into economic activity and so total primary energy supply (TPES) is driven by the state of the economy. Periods of economic growth are commonly characterised by an increase in energy-consuming activities, and in emerging economies with an increase in emissions-intensive activities, for example manufacture and construction. This is usually partly offset by an increase in energy efficiency. A decline in the carbon intensity of TPES can be achieved through transition to low and zero carbon sources of energy, increased energy efficiency or a change in economic structure. South Africa's carbon intensity of TPES has not declined since the start of the century, despite a drop in emissions intensity (emissions/unit of economic output). This indicates that South Africa is still in the very early stages of a transition to a lower-carbon economy.

Data

Table 2.5.1: Greenhouse gas emissions per unit of total primary energy supply (t CO_2/TJ).

	Tonnes of CO_2eq per unit TPES (t CO_2eq/TJ)	TTPES (TJ)	Energy-related emissions (t CO_2eq)
2000	75	4 298 220	321 300
2001	81	3 972 681	321 668
2002	72	4 637 437	333 732
2003	80	4 507 518	359 182
2004	72	5 240 908	375 630
2005	74	5 078 962	375 412
2006	69	5 536 470	383 234
2007	76	5 449 933	414 139
2008	43	9 589 296	409 503
2009	67	6 239 887	419 255
2010	73	5 954 835	436 162
2011	72	5 725 554	412 539
2012	75	5 667 723	425 489
2013	74	5 938 809	441 636
2014	70	6 255 086	438 281
2015	75	5 783 907	432 511

Data notes

Emissions included are from fuel combustion for energy industries, manufacturing industries and construction, transport, other sectors and from fugitive emissions. The anomalous total for 2008 is thought to be an error, but no further documentation is available.

Numbers have been rounded to the nearest whole number.

Data sources

Department of Environmental Affairs (2018). South Africa's Greenhouse Gas Inventory Report 2000-2015. Department of Environmental Affairs. Pretoria, South Africa. Retrieved from https://www.environment.gov.za/sites/default/files/reports/GHG-National-Inventory-Report- SouthAfrica-2000-2015.pdf

Department of Energy, (no date) Consolidated Aggregated Historical Energy Balances per commodity. Microsoft Excel File. Retrieved from http://www.energy.gov.za/files/energyStats_frame.html

Indicator status and recommendations for the way forward

Tier I

INDICATOR 2.6: ELECTRICITY GENERATION TECHNOLOGY MIX

Indicator definition

The change in the shares of fossil fuel and renewable electricity generation in the national electricity supply.

Indicator rationale

Around 45% of South Africa's GHG emissions are produced by electricity generation, which has also been identified as the key sector for cost-effective mitigation over the next few decades. Tracking the source of South Africa's electricity by technology is thus a key indicator for the extent and speed of South Africa's decarbonisation.

Data visualisation

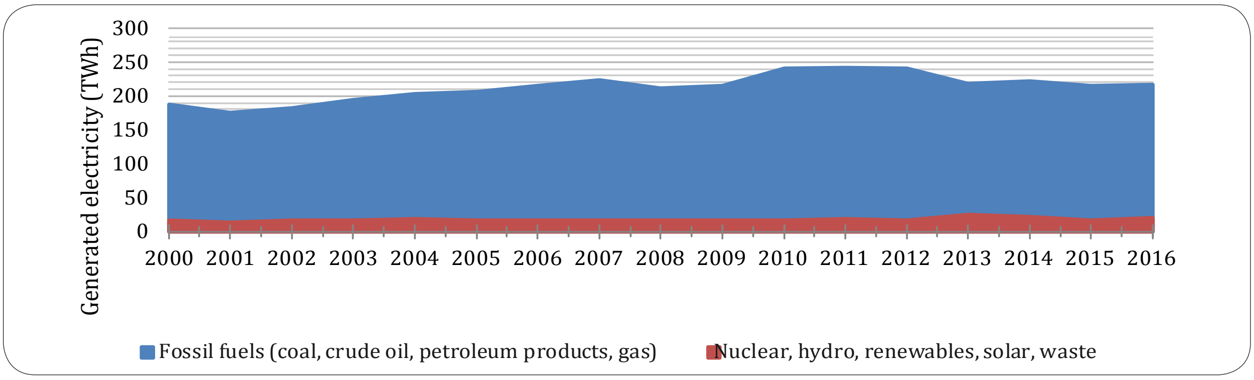

Figure 2.6.1: Electricity output from fossil fuel and from low carbon sources.

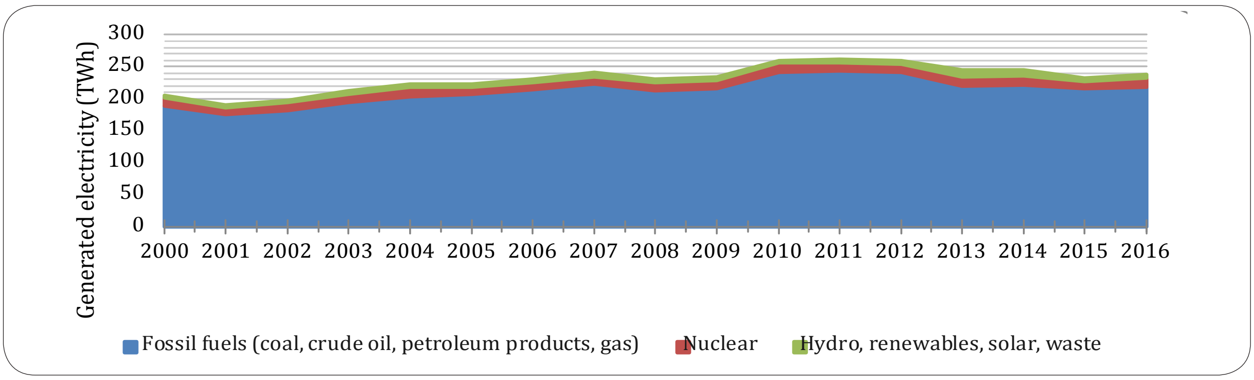

Figure 2.6.2: Electricity output from fossil fuel, nuclear, and renewable sources.

Analysis

South Africa produces 91% of its electricity from coal. In contrast, renewables including hydro, make up 4.5% of electricity supply. The renewable energy fraction is projected to increase significantly as IRP 2019 is implemented.

Data notes

Energy balance data is less accurate than data sourced directly from electricity producers, but currently such data is not publicly available for the whole electricity sector.

Numbers are rounded to the nearest whole number.

Data

Table 2.6.1: Electricity output in terrawatt hours (GWh) from fossil fuel and low carbon fuels.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Fossil fuels (coal, crude oil, petroleum products, gas)	188	175	182	194	204	207	214	223	212	216	241	242	242	219	221	216
Nuclear, hydro, renewables, solar, waste	17	14	17	17	19	16	17	18	18	18	18	19	18	26	23	17

Table 2.6.2: Electricity output in terrawatt hours (TWh) from renewable, nuclear and fossil fuel sources.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Fossil fuels (coal, crude oil, petroleum products, gas)	188	175	182	194	204	207	214	223	212	216	241	242	242	219	221	216
Nuclear	13	11	12	13	13	11	10	11	13	13	14	13	13	14	14	11
Hydro, renewables, solar, waste	4	4	5	5	6	5	7	7	5	5	4	6	5	11	9	5

Data sources

Department of Energy, (no date) Consolidated Aggregated Historical Energy Balances per commodity. Microsoft Excel File. Retrieved from http://www.energy.gov.za/files/energyStats_frame.html

Indicator status and recommendations for the way forward

Tier 1

INDICATOR 2.7: WATER INTENSITY OF ELECTRICITY PRODUCTION

2.7

Indicator definition

Water used per unit of electricity sent out by Eskom power plants.

Indicator rationale

The electricity sector in South Africa uses around 1.5% of the country's water annually (Eskom, 2006). Water use is primarily associated with the generation of electricity by coal plants. As we transition to renewable energy technologies such as PV, water use by the sector will drop significantly.

Data visualisation

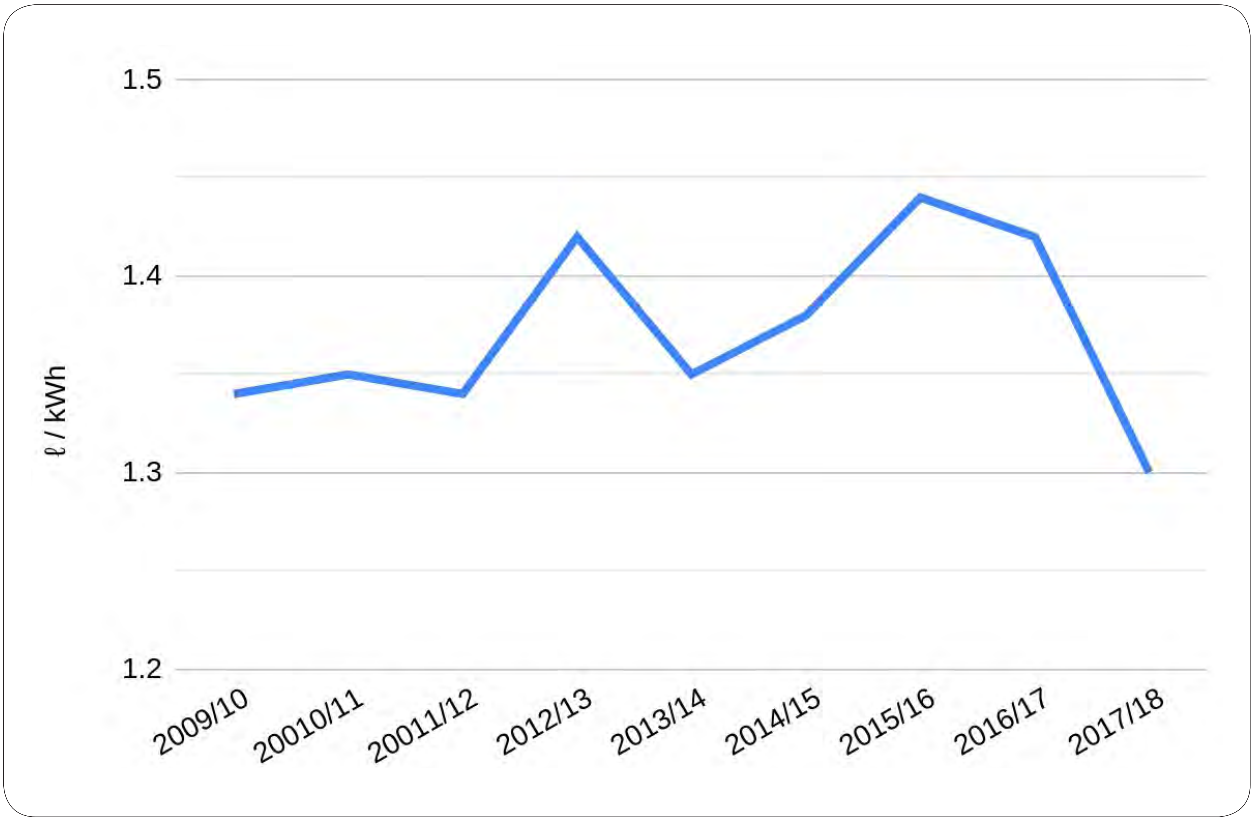

Figure 2.7.1: Water intensity of electricity production sent out by Eskom.

Analysis

Water intensity of electricity production has not changed significantly in the last decade but should gradually decline as more PV and wind capacity comes online. Explanations are not provided for short-term fluctuations but could stem from fluctuating use of open-cycle gas turbines and the fluctuating efficiency of Eskom's coal fleet.

Data notes

The data here is for Eskom power plants only (therefore excluding water use by municipal plants, on-site generators or IPPs), and is reported for Eskom's financial year (April-March) rather than the calendar year (January-December). Fresh water is used primarily for cooling by Eskom's fleet of coal plants. Water use data here reflects water use in the plants themselves (primarily for cooling) and excludes any water used for coal processing/production.

Numbers have been rounded to the second decimal point.

Data

Table 2.7.1: Water intensity of electricity sent out (l/kWh) and water consumption (Ml) of Eskom.

	2008/09	2009/10	2010/11	20011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
Specific water consumption (ℓ/kWh sent out)	1.35	1.34	1.35	1.34	1.42	1.35	1.38	1.44	1.42	1.3
Net raw water consumption (Mℓ)	323 190	316 202	327 252	319 772	334 275	317 052	313 078	314 685	307 269	276 335

Data sources

Eskom, (2018) Integrated Report. Retrieved from http://www.eskom.co.za/OurCompany/Investors/IntegratedReports/Pages/Annual_Statements.aspx

Eskom, (no date) Water Management. Webpage. Retrieved from http://www.eskom.co.za/OurCompany/SustainableDevelopment/Pages/Reduction_In_Water_Consumption.aspx

Indicator status and recommendations for the way forward

Tier 1

INDICATOR 2.7.1: ENERGY-RELATED AIR POLLUTION

2.7.1

Indicator definition

This indicator tracks levels of energy-related air pollution.

Indicator rationale

Energy-related activities, including mining, industry, power generation and transportation, among others, all pollute the air and there is a wide range of evidence documenting the negative health and economic impacts of energy-related air pollution. South Africa formally recognises three Priority Areas (PAs) as having air quality that is consistently hazardous to human health, and where energy-related activities make a major contribution to this problem. These are the Vaal Triangle Airshed Priority Area (VTAPA), the Highveld Priority Area (HPA) and the Waterberg Bojanala Priority Area (WBPA).

There are a number of air quality monitoring stations across the country that track concentrations of ambient air pollutants. These monitors are located where air pollution is likely to be an issue because of proximity to sources of pollution and a likelihood of human exposure. Levels of concentrations of harmful pollutants are assessed against National Ambient Air Quality Standards (NAAQS). The NAAQS identifies a level of pollutant concentration above which exposure can be detrimental to human health. This varies between pollutants.

To understand the severity of the ambient air quality problem in Priority Areas, across a number of monitoring stations (between four and six for each PA) and across four pollutants, an Air Quality Index (AQI) is developed for each pollutant at each monitoring station. The AQI is the annual average concentration of an air pollutant normalised against the NAAQS. The indicator includes information about how many of the stations report sufficient data each year for this assessment and the

percentage of these annual retrievals that exceed the NAAQS.

This indicator reveals the percentage of station monitoring reports within the PAs with annual average concentrations of ambient pollution that exceed 'safe' levels of concentrations identified by the NAAQS. It tracks the highest AQI for each PA and the four pollutants reported here. This is an indication of the worst ambient air quality, on average over the year within each PA.

Transition to a lower-carbon economy brings co-benefits of cleaner air as a result of reduced pollution from energy-related activities. This indicator tracks the greatest extent to which ambient air quality exceeds the NAAQS for any of four pollutants at every monitoring station within each PA. It also gives an idea of how widespread this issue is within the PAs.

Data visualisation

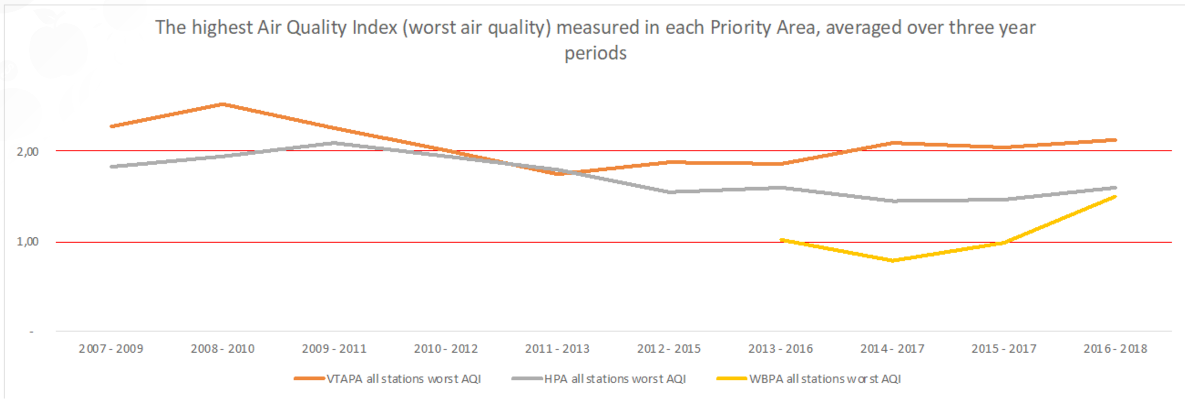

Figure 2.7.1.1: The highest Air Quality Indicator (worst ambient air quality) measured in each Priority Area.

Data

Table 2.7.1.1: The highest Air Quality Index (worst ambient air quality) measured in each Priority Area.

	2007 - 2009	2008 - 2010	2009 - 2011	2010 - 2012	2011 - 2013	2012 - 2015	2013 - 2016	2014 - 2017	2015 - 2017	2016 - 2018
VTAPA all stations	2,29	2,53	2,26	2,02	1,75	1,89	1,87	2,10	2,05	2,14
HPA all stations	1,83	1,96	2,09	1,95	1,81	1,55	1,61	1,46	1,46	1,60
WBPA all stations							1,01	0,78	0,99	1,50

Table 2.7.1.2: Vaal Triangle Airshed Priority Area (VTAPA).

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Pollutant with maximum exceedance of NAAQS	PM2.5 [µg/m³]											
VTAPA all stations worst AQI	1,83	2,32	2,72	2,56	1,50	1,99	1,74	1,93	1,93	2,44	1,79	2,19
VTAPA maximum annual average NO_2	1,17	1,07	1,16	1,06	0,78	1,01	1,39	1,06	1,44	1,14	1,21	0,91
VTAPA maximum annual average PM10	1,58	2,05	2,56	1,98	1,39	1,99	1,65	1,63	1,60	2,44	0,95	1,63
VTAPA maximum annual average PM2.5	1,83	2,32	2,72	2,56	1,50	1,99	1,74	1,93	1,93	1,77	1,79	2,19
VTAPA maximum annual average SO_2	0,49	0,44	0,48	0,43	0,40	0,49	0,44	0,47	0,42	0,43	0,32	0,44

Table 2.7.1.3: Highveld Priority Area (HPA) maximum AQI across monitor stations for each pollutant.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Pollutant with maximum exceedance of NAAQS		PM2.5 [μg/m³]	PM10 [μg/m³]								
HPA all stations worst AQI	**1,71**	**1,95**	**2,21**	**2,11**	**1,52**	**1,79**	**1,34**	**1,68**	**1,34**	**1,36**	**2,11**
HPA maximum annual average NO_2	-	**1,49**	0,96	0,60	0,60	0,92	0,71	0,86	0,74	0,56	0,88
HPA maximum annual average PM10	**1,71**	**1,82**	**2,21**	**2,11**	**1,52**	**1,79**	**1,34**	**1,68**	**1,34**	**1,36**	**2,11**
HPA maximum annual average PM2.5	-	**1,95**	**1,93**	**1,91**	**1,38**	**1,47**	**1,28**	**1,38**	**1,15**	**1,20**	**1,76**
HPA maximum annual average SO_2	-	**1,00**	**1,01**	**1,45**	0,99	0,95	**1,00**	0,98	0,76	0,51	0,70

Table 2.7.1.4: Waterberg Bojanala Priority Area (WBPA) maximum AQI across monitor stations for each pollutant.

	2013	2014	2015	2016	2017	2018
Pollutant with maximum exceedance of NAAQS	PM10 [μg/m^3]					PM2.5 [μg/m^3]
WBPA all stations worst AQI	**1,40**	0,92	0,72	0,71	**1,54**	**2,27**
WBPA maximum annual average NO_2	0,36	0,32	0,40	0,48	0,37	0,37
WBPA maximum annual average PM10	**1,40**	0,92	0,72	0,71	**1,54**	**1,64**
WBPA maximum annual average PM2.5	**1,36**	0,86	0,70	0,68	0,97	**2,27**
WBPA maximum annual average SO_2	0,13	0,11	0,14	0,17	0,15	0,17

Table 2.7.1.5: Assessment of how widespread the ambient air quality problem is within the PAs in 2018.

	number of retrievals	possible retrievals	% of retrievals exceed NAAQS	in 2018, AQIs were exceeded at:
VTAPA (five stations, four pollutants)	19	20	20%	four of the five stations
HPA (six stations, four pollutants)	24	24	67%	six of the six stations
WBPA (four stations, four pollutants)	16	16	6%	three of the four stations
Totals	**59**	**60**	**36%**	**13 of the 15 stations**

Data notes

The South African Air Quality Information System (SAAQIS) reports localised Air Quality Index (AQI) in line with best international practices.

Air quality monitoring stations are not evenly spread over the Priority Areas. They are located in areas where air quality is a likely concern because of both poor air quality and because there are people who are likely to be exposed to the pollution. This means that monitor data does not represent all of the Priority Area, of which some may have better or worse air quality. Monitor data also gives uneven representation of air quality in time. Reporting by monitoring stations may be inconsistent, for example when there is disruption to electricity supply to the monitoring stations.

It is assumed that only monitors with validated data for more than 70% of the retrieval period are included in the calculation for the annual average. Changes in the number of monitors that meet data quality criteria, or the location of monitors in future years, might affect data in some years.

Data sources

Ambient air quality data is available from the South African Air Quality Information System (https://saaqis.environment.gov.za/).

National Ambient Air Quality Standards are published by the Minister of Environmental Affairs in terms of section 9(1) of the Air Quality Act (see Government Gazette No. 32816 of 24 December 2009 and Gazette No. 35463 of 29 June 2012).

Indicator status and recommendations for the way forward

Tier I

INDICATOR 2.8: TRANSPORT EMISSIONS PER CAPITA

2.8

Indicator definition

Total emissions from the transport sector divided by the total population.

Indicator rationale

Transport emissions per capita currently indicate both the provision of transport services (level of development), their efficiency and in the longer term, decarbonisation trends. South Africa's transport emissions per capita are close to the world average but are high for a developing country.

Data visualisation

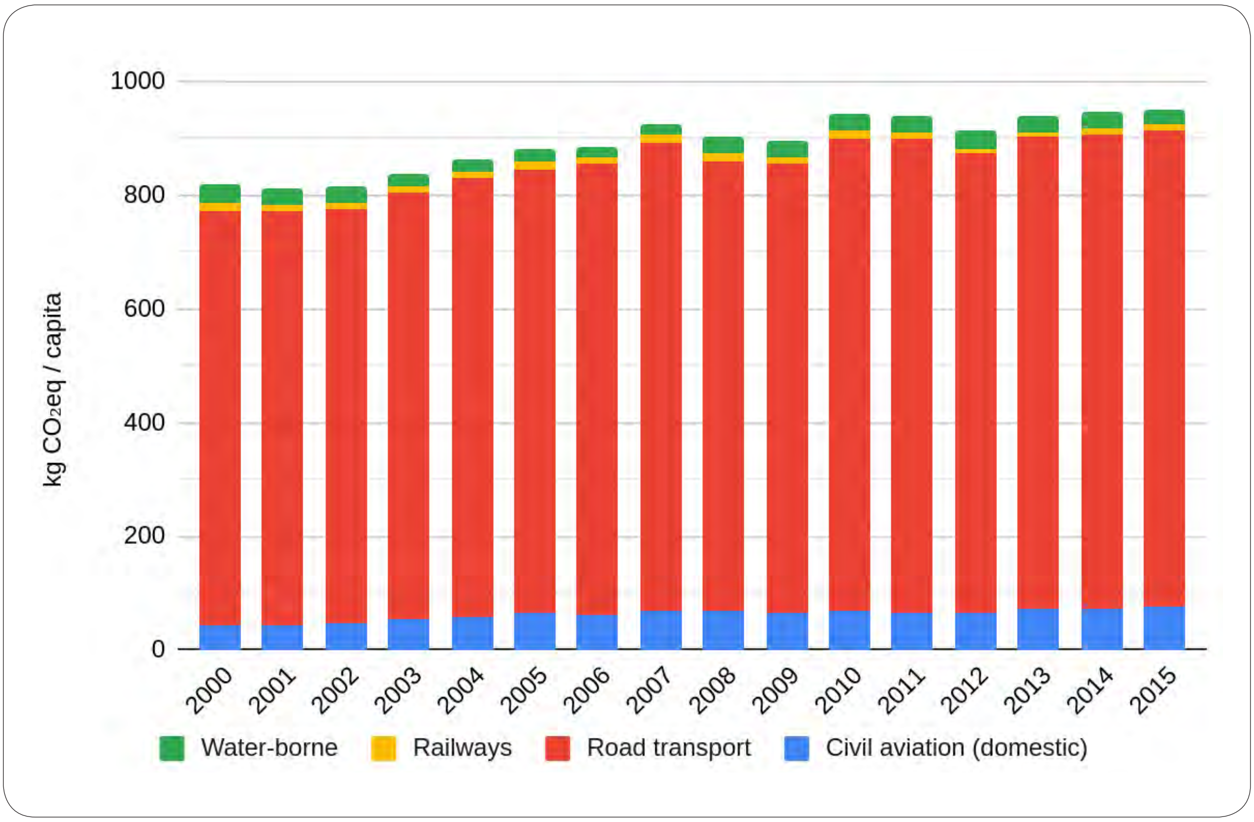

Figure 2.8.1: Per capita GHG emissions from transport sources.

Analysis

South African transport emissions are overwhelmingly from road transport, and other than aviation emissions, have remained relatively stable per capita since 2000.

Data notes

Transport emissions per capita were calculated by dividing the total emissions per transport category by the total population.

Numbers have been rounded to the nearest whole number.

Data

Table 2.8.1: Per capita GHG emissions from transport sources (kg CO_2eq / capita).

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Civil aviation (domestic)	45	45	47	56	59	65	63	68	68	67	70	67	64	72	74	75
Road transport	729	726	729	751	770	782	794	826	791	789	829	833	810	830	835	839
Railways	14	13	13	12	12	12	11	14	15	12	15	11	10	10	11	11
Water-borne	33	29	26	20	23	23	18	19	30	28	29	31	30	27	27	27
All transport	820	813	815	838	865	882	886	927	904	897	943	942	913	940	947	952

Data sources

Statistics South Africa, (2019). Mid-year population estimates. Statistics South Africa. Pretoria, South Africa. Retrieved from http://www.statssa.gov.za/?page_id=1866&PPN=P0302&SCH=7668

Department of Environmental Affairs (2018). South Africa's Greenhouse Gas Inventory Report 2000-2015. Department of Environmental Affairs. Pretoria, South Africa. Retrieved from https://www.environment.gov.za/sites/default/files/reports/GHG-National-Inventory-Report- SouthAfrica-2000-2015.pdf

Indicator status and recommendations for the way forward

Tier 1

INDICATOR 2.9: TRANSPORT ENERGY MIX

2.9

Indicator definition

The use of energy by fuel type in the South African transport sector.

Indicator rationale

Fuel use in the transport sector will shift gradually from liquid fuels to other lower- and zero-carbon fuels (natural gas, biofuels, electricity, hydrogen) as the sector decarbonises.

Data visualisation

Figure 2.9.1: Final energy consumption of transport by energy source.

Analysis

Transport in South Africa relies almost entirely on fossil-derived liquid fuels and use of these has grown dramatically since 1995. Transport is expected to electrify over the next three decades, which will see a significant decline in the use of such liquid fuels and a concomitant rise in the use of electricity for transport.

Data notes

This data is extracted directly from the Aggregated Historical Energy Balances, Data sources for the GHG National Inventory Report 2000-2015 are not consistent with the national energy balances for transport fuels.

Numbers have been rounded to the nearest whole number, or second decimal point for gas and coal data.

Data

Table 2.9.1: Final energy consumption of transport by source (PJ/year).

	Gas	Coal	Petroleum products	Electricity
2000	0,03	0,00	584	19
2001	0,03	0,07	601	20
2002	0,03	0,00	614	22
2003	0,00	0,00	636	20
2004	0,00	0,00	676	23
2005	0,00	0,00	691	20
2006	0,00	0,00	714	13
2007	0,00	3,59	776	24
2008	0,00	5,50	924	13
2009	0,00	2,04	900	13
2010	0,00	6,34	735	13
2011	0,00	2,25	741	14
2012	0,01	0,58	746	14
2013	0,00	0,59	816	13
2014	0,00	0,46	785	13
2015	0,00	0,40	832	12
2016	0,00	0,39	557	11
2017	0,00	0,04	761	12

Data sources

Department of Energy, (no date) Consolidated Aggregated Historical Energy Balances per commodity. Microsoft Excel File. Retrieved from http://www.energy.gov.za/files/energyStats_frame.html. Data in rows for 'Transport sector' within each energy source data sheet.

Indicator status and recommendations for the way forward

Tier I

INDICATOR 2.10: DOMESTIC AVIATION EMISSIONS PER CAPITA

Indicator definition

Domestic aviation emissions (from flights departing and arriving in South Africa) per capita of the total population.

Indicator rationale

Rising domestic aviation emissions are simultaneously an indication of a growing South African middle class, a growing tourism industry and a source of concern for future emissions. This also indicates a lack of availability of other less emission-intensive modes of transport such as effective intercity train services.

Data visualisation

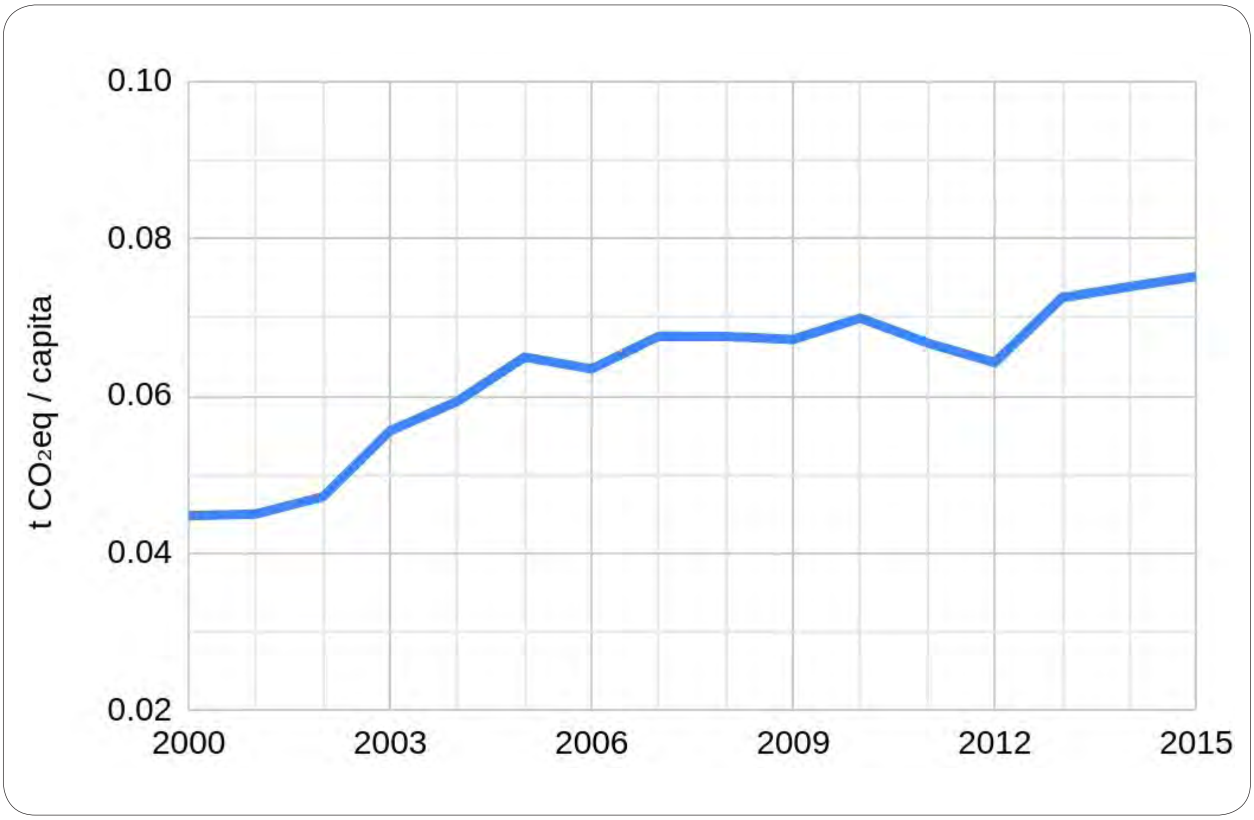

Figure 2.10.1: National GHG emissions from local civil aviation.

Analysis

Domestic aviation emissions have risen steadily over the last decade and a half, partially offset by low economic growth and increasing aircraft fuel efficiency.

Data notes

GHG emissions – only emissions from domestic aviation used (IPCC 2006 category 1A3a). Numbers have been rounded to the third decimal point.

Data

Table 2.10.1: National GHG emissions from local civil aviation.

	Civil aviation (local) emissions per capita (t CO_2eq/capita)	Civil aviation, national emissions (gG CO_2eq)	Country population
2000	0.045	2 047	45 765 710
2001	0.045	2 079	46 243 716
2002	0.047	2 204	4741 256
2003	0.056	2 626	47 268 914
2004	0.059	2 837	4839 908
2005	0.065	3 147	48 476 016
2006	0.063	3 118	49 176 550
2007	0.068	3 374	49 928 233
2008	0.068	3 425	50 724 112
2009	0.067	3 463	51 550 684
2010	0,.070	3 662	52 409 724
2011	0.067	3 554	53 282 289
2012	0.064	3 479	54 166 787
2013	0.072	3 990	55 055 626
2014	0.074	4 132	55 946 872
2015	0.075	4 273	56 837 474

Data sources

Department of Environmental Affairs (2018). GHG National Inventory Report South Africa 2000-2015. Department of Environmental Affairs. Pretoria, South Africa. Retrieved from https://www.environment.gov.za/sites/default/files/reports/GHG-National-Inventory-Report-SouthAfrica-2000-2015.pdf

Statistics South Africa, (2019). Mid-year population estimates. Statistics South Africa. Pretoria, South Africa. Retrieved from http://www.statssa.gov.za/?page_id=1866&PPN=P0302&SCH=7668

Indicator status and recommendations for the way forward

Tier 1

INDICATOR 2.11: MOTORISATION RATE

2.11

Indicator definition

The number of private motor vehicles per 1000 inhabitants.

Indicator rationale

Transport emissions are growing in South Africa. The rate of motorisation provides information about private vehicle ownership as a driver of transport emissions.

Data visualisation

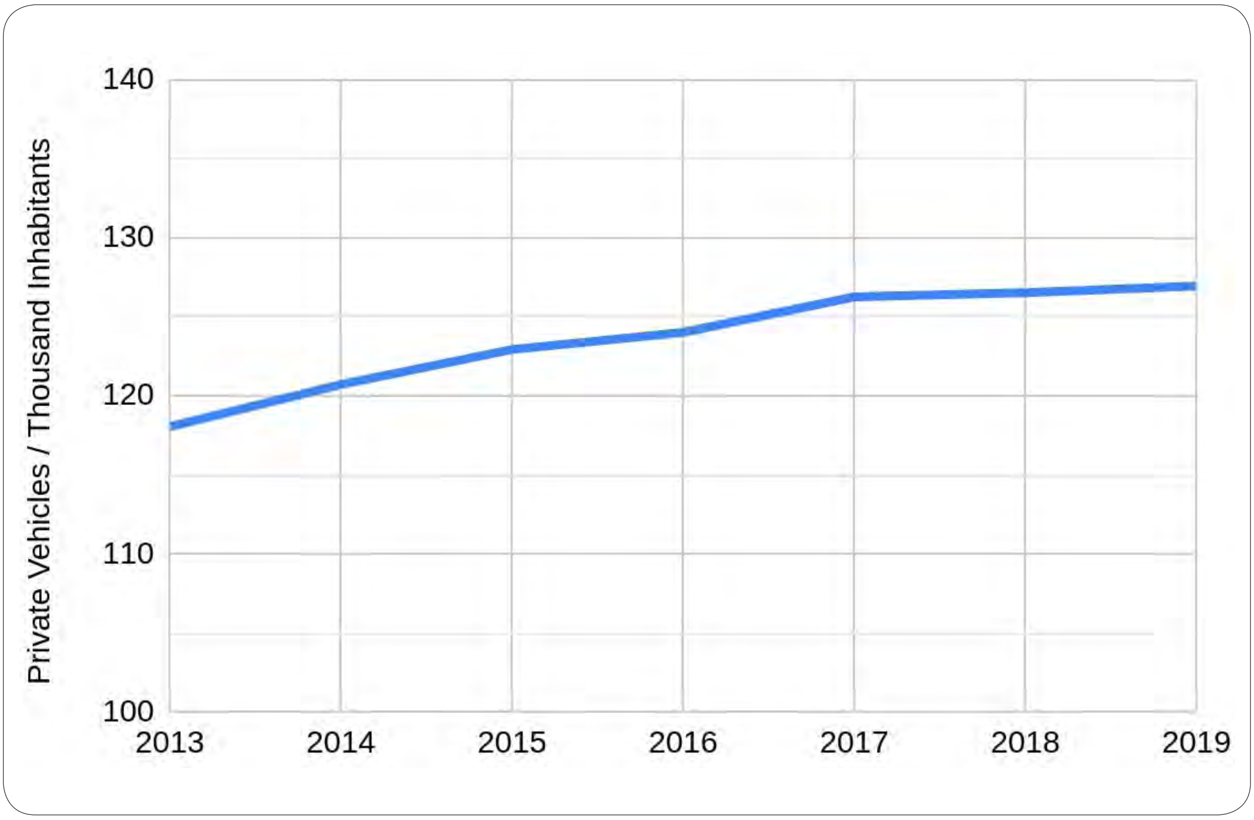

Figure 2.11.1: Number of privately registered vehicles registered per thousand inhabitants.

Analysis

It is estimated that there are 127 private vehicles per 1000 people in South Africa. This rate of motorisation shows an increase over time, however, since 2017 the rate has become slower. This increasing trend of motorisation will increase transport emissions if the shift to lower/zero-carbon is not made. According to international estimates the global average rate of motorisation is 182 vehicles per 1000 inhabitants.

Data notes

This assessment assumes that private vehicles include all the motor cars and station wagons that are registered each year, and no other vehicles.

Numbers have been rounded to the nearest whole number.

Data

Table 2.11.1: The number of privately registered vehicles per thousand inhabitants (motorisation rate), number of vehicles and population.

	2013	2014	2015	2016	2017	2018	2019
Motor cars and station wagons	6 344 849	6 587 787	6 811 058	6 975 703	7 136 471	7 304 083	7 461 493
Population	53 751 096	54 574 401	54 574 401	56 252 336	56 521 948	57 725 606	58 775 022
Motorisation rate	118	121	123	124	126	127	127

Data sources

National Traffic Information System, (2013-2019). eNaTIS Statistics for live vehicle population [Dataset]. Retrieved from http://www.enatis.com/index.php/statistics/13-live-vehicle-population

Statistics South Africa, (2019). Mid-year population estimates. Statistics South Africa. Pretoria, South Africa. Retrieved from http://www.statssa.gov.za/?page_id=1866&PPN=P0302&SCH=7668

Indicator status and recommendations for the way forward

Tier 1

INDICATOR 2.12: MARKET SHARE OF ELECTRIC VEHICLES IN NEW CAR SALES

2.12

Indicator definition

The market share of electric cars (battery-electric vehicles and plug-in electric hybrids) of total vehicle sales.

Indicator rationale

Electric vehicle market share is an indicator of the rate at which South Africa's car fleet is shifting to low-carbon vehicles, and ultimately to the decarbonisation of the vehicle fleet.

Data visualisation

Analysis

Market penetration of battery electric vehicles and plug-in hybrid electric vehicles is extremely low in South Africa, and has not changed significantly in recent years. According to the International Energy Agency Norway leads the electric vehicles market and in 2015 39% of their vehicles were powered by electricity.

Data

Table 2.12.1: The market share of electric vehicles as a percentage of new car sales in 2015-18.

	2015	2016	2017	2018
Percentage of battery electric vehicles and plug-in hybrid electric vehicles as a share of registered live vehicles (%)	0,06	0,10	0,05	0,06

Data notes

International Energy Agency estimates are based on analyses of the development of the EV market until the end of 2017, covering EV registrations (vehicle sales) and EV stock estimates (mainly based on cumulative sales).

Data sources

International Energy Agency, (2019). Global EV Outlook 2019. IEA. Retrieved from https://www.iea.org/reports/global-ev-outlook-2019. Table named: 'Market share of electric cars (BEV and PHEV) by country, 2005-18 (%)'

Indicator status and recommendations for the way forward

Tier 1

2.13 INDICATOR 2.13: INDUSTRY EMISSIONS INTENSITY

Indicator definition

Intensity of GHG emissions per unit of GDP from industry.

Indicator rationale

South Africa's industrial sector is one of the key sources of GHG emissions. A declining emissions intensity will indicate that the industrial sector is either moving away from emissions-intensive subsectors, becoming more efficient, or using lower-carbon energy sources and processes, or more than one of these.

Data visualisation

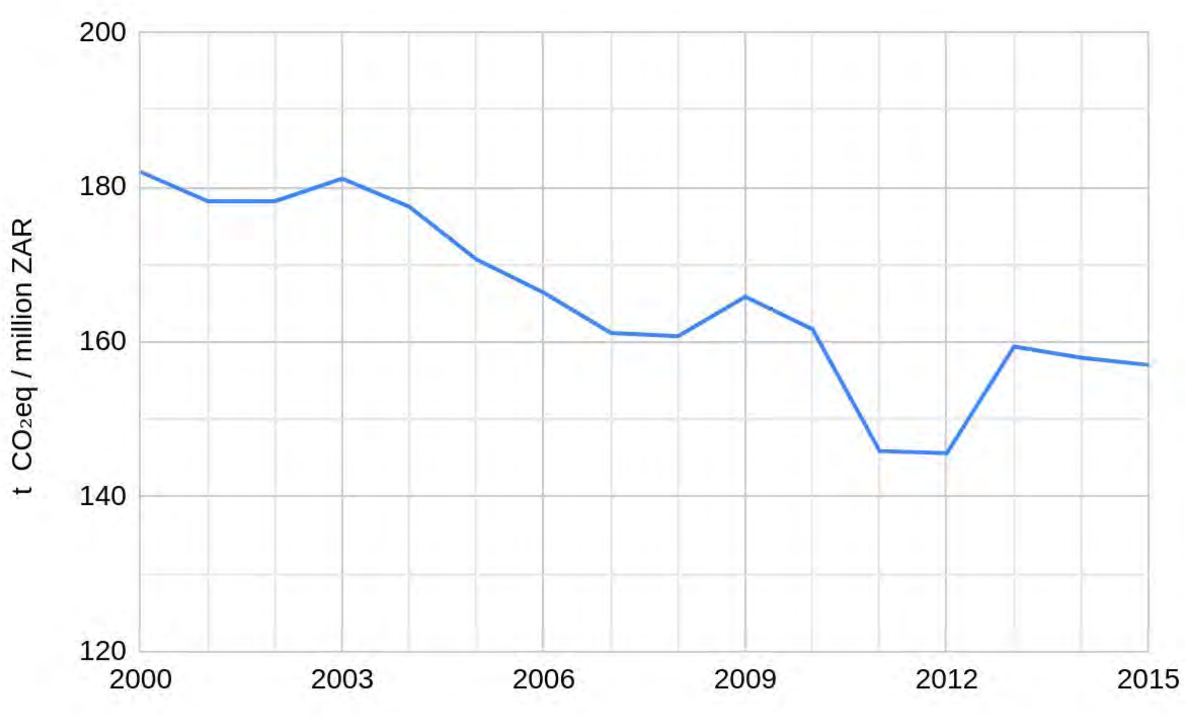

Figure 2.13.1: Industry GHG emissions for each million rand value of gross domestic product.

Analysis

The emissions intensity of the industrial sector has declined slightly since 2002, indicating that emissions growth from the sector has not kept pace with the economic growth of the sector itself. This is probably an indicator of less investment in energy-intensive projects, combined with a gain in efficiency.

Data notes

The Greenhouse Gas National Inventory Report includes the subcategories listed below (subcategories are defined in terms of the 2006 IPCC Guidelines for the compilation of national GHG inventories.)

1.A.1.b – Petroleum Refining, 1.A.1.c – Manufacture of Solid Fuels and Other Energy Industries, 1.A.2 – Manufacturing Industries and Construction, 2 - Industrial Processes and Product Use Numbers have been rounded to the nearest whole number.

Data

Table 2.13.1: Industry GHG emissions for each million rand value of gross domestic product.

	Emissions from the manufacturing and construction sector, from manufacture of solid fuels and other energy industries, and from petroleum refining (Gg CO_2eq)	Gross Domestic Product by industry for mining and quarrying for manufacturing for construction (R Million)	Gross Domestic Product by industry for mining and quarrying for manufacturing for construction (R Million)
2000	10 135 500	55 697 930	182
2001	10 118 500	56 792 980	178
2002	10 352 700	581 033	178
2003	10 649 600	588 047	181
2004	10 840 200	610 837	177
2005	10 909 800	639 272	171
2006	11 074 000	665 577	166
2007	11 177 500	693 507	161
2008	11 202 500	696 927	161
2009	10 817 700	652 281	166
2010	11 065 200	684 502	162
2011	10 128 400	694 087	146
2012	10 161 500	697 650	146
2013	11 394 300	714 763	159
2014	11 306 000	715 692	158
2015	11 360 200	723 389	157

Data sources

Department of Environmental Affairs (2018). South Africa's Greenhouse Gas Inventory Report 2000-2015.

Department of Environmental Affairs. Pretoria, South Africa. Retrieved from https://www.environment.gov.za/sites/default/files/reports/GHG-National-Inventory-Report-SouthAfrica-2000-2015.pdf

Gross Domestic Product Data - Department of Statistics South Africa (2019). Statistical Release P0441: Gross Domestic Product (GDP) 3rd Quarter 2019, time series data (Excel - Gross Domestic Product (Quarterly) (2019Q3)). Statistics South Africa. Pretoria, South Africa. Retrieved from http://www.statssa.gov.za/?page_id=1866&PPN=P0441&SCH=7695

Indicator status and recommendations for the way forward

Tier 1

INDICATOR 2.14: PRIMARY FUELS FOR COOKING

2.14

Indicator definition

The number of households using various sources of energy for cooking.

Indicator rationale

Households require energy for three main tasks: cooking, heating and lighting. Electricity is an ideal source of energy for all these tasks, but households without access to electricity or means to afford electricity will use alternative sources of energy. The use of wood or coal for cooking in the home can be a harmful source of air pollution because of the enclosed space. Women preparing food and young children in their care are among the most vulnerable to respiratory health impacts of these cooking fuels. The use of coal and wood for cooking is a cross-cutting indicator that links to poverty, development and to the transition to clean low-carbon fuels.

Data visualisation

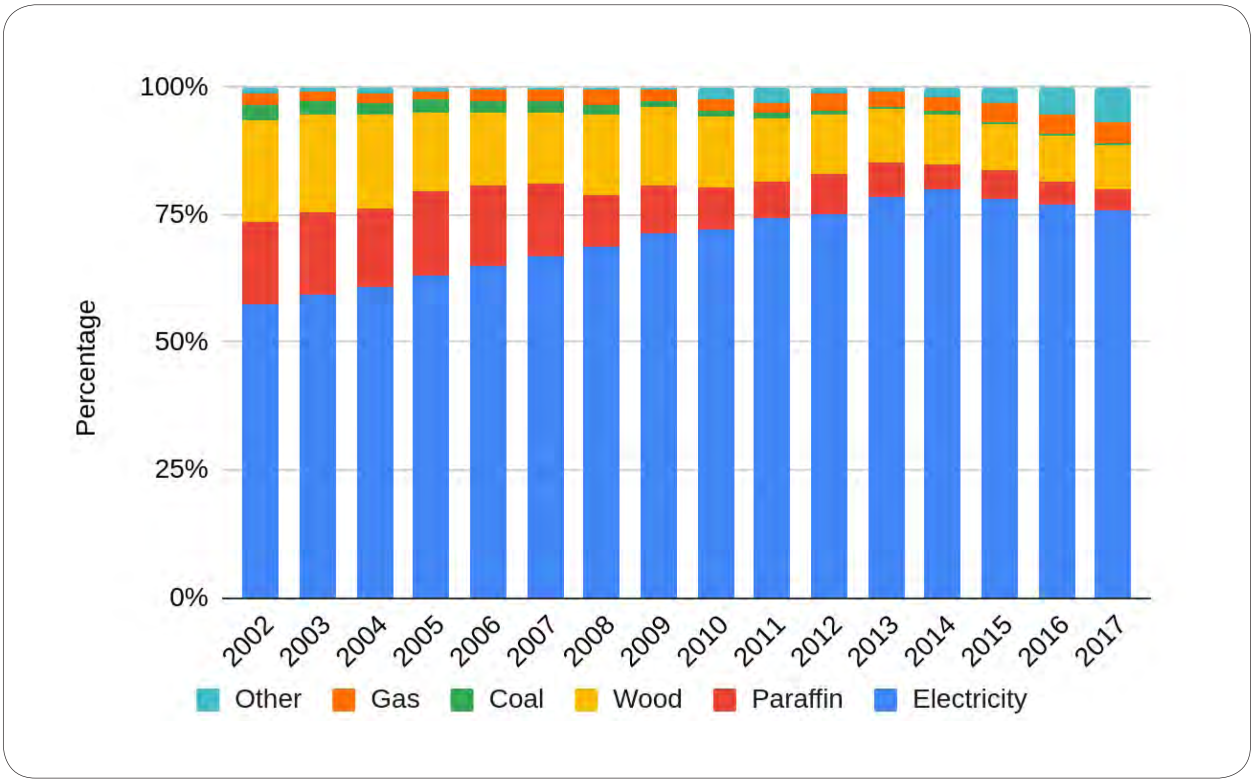

Figure 2.14.1: Percentage distribution of main sources of energy used for cooking in South Africa.

Analysis

There has been a steady increase in electricity as a contributor to energy used for cooking since 2002, with significant decreases in paraffin, wood and coal. However, since 2013/2014 the picture changes, with electricity contributions moving towards a decrease, wood and gas contributions staying relatively constant and gas and 'other' energy sources increasing. The shift away from wood, from which direct air pollution can be especially harmful, seems to have slowed, while electricity users are potentially shifting into the use of gas.

Data notes

In the data it is unclear what the category 'other' sources of energy includes. Percentage numbers have been rounded to the first decimal point.

Data sources

Stats SA, 2018. General Household Survey, Statistical Release P0318. Statistics South Africa, Pretoria. Retrieved from http://www.statssa.gov.za/?page_id=1866&PPN=P0318&SCH=7652

Data

Table 2.14.1: Percentage distribution of main sources of energy used for cooking in South Africa by year, 2002-2017.

	Electricity	Paraffin	Wood	Coal	Gas	Other
2002	57,5%	16,1%	20,0%	3,0%	2,2%	1,2%
2003	59,5%	15,8%	19,3%	2,7%	1,6%	1,1%
2004	60,7%	15,4%	18,4%	2,4%	1,7%	1,4%
2005	62,9%	16,5%	15,6%	2,4%	1,8%	0,8%
2006	64,9%	15,9%	14,3%	2,1%	2,2%	0,6%
2007	67,0%	14,1%	13,9%	2,2%	2,2%	0,6%
2008	68,6%	10,3%	15,8%	1,8%	3,0%	0,6%
2009	71,4%	9,4%	15,1%	1,3%	2,2%	0,5%
2010	72,1%	8,4%	13,7%	1,2%	2,2%	2,5%
2011	74,2%	7,0%	12,6%	0,9%	2,1%	3,1%
2012	75,2%	7,8%	11,6%	0,8%	3,3%	1,3%
2013	78,4%	6,8%	10,4%	0,4%	3,2%	0,8%
2014	79,9%	5,0%	9,7%	0,6%	2,7%	2,1%
2015	78,2%	5,4%	9,1%	0,5%	3,5%	3,3%
2016	76,9%	4,7%	8,8%	0,5%	3,8%	5,4%
2017	75,9%	4,2%	8,4%	0,4%	4,2%	6,9%

Indicator status and recommendations for the way forward

Tier 1

INDICATOR 2.15: ENERGY SOURCES USED FOR LIGHTING

Indicator definition

The main sources of energy used for lighting.

Indicator rationale

Having adequate and affordable access to energy sources is vital to address poverty. Tracking the sources of energy for lighting measures access to electricity supplied by the national grid. This indicator shows the relative use of low-carbon sources, like solar energy. It also reveals the extent of the use of fuels that are associated with concerns about safety and health, such as paraffin, coal and animal dung.

Data visualisation

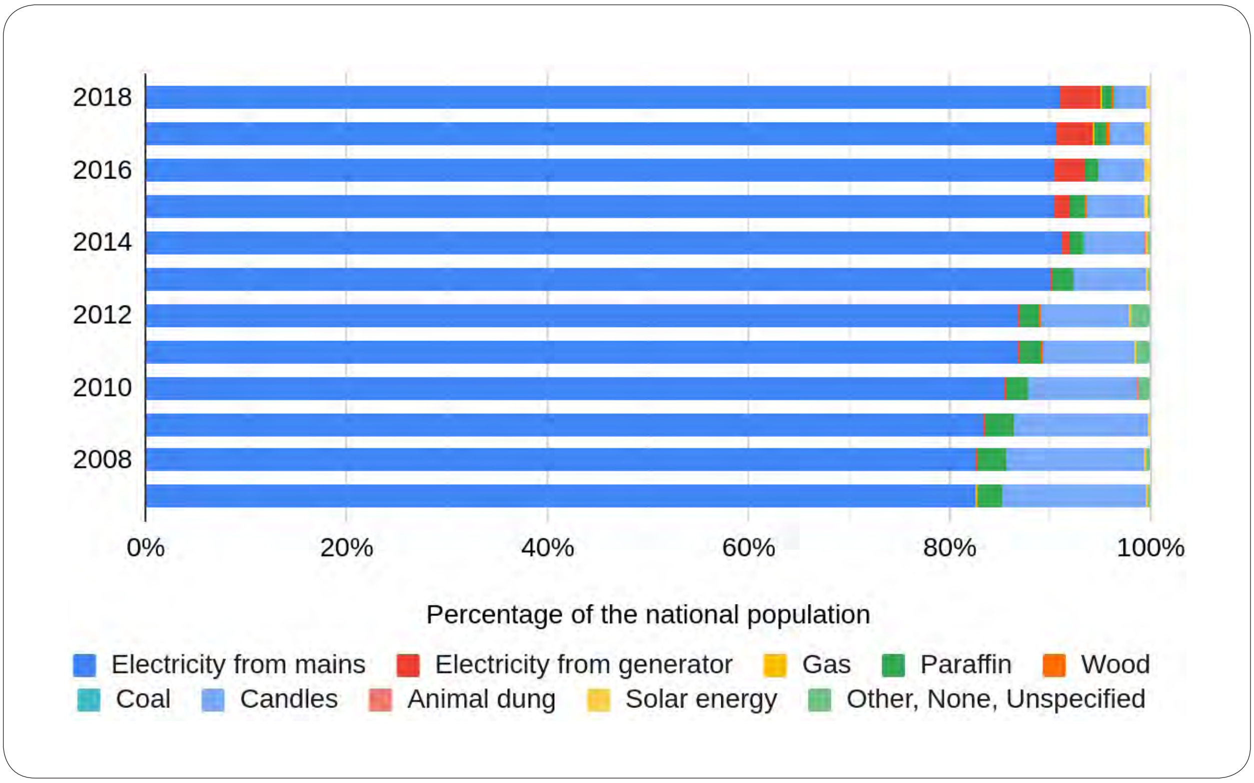

Figure 2.15.1: Percentage of the population that use each energy source as their main source of energy for lighting.

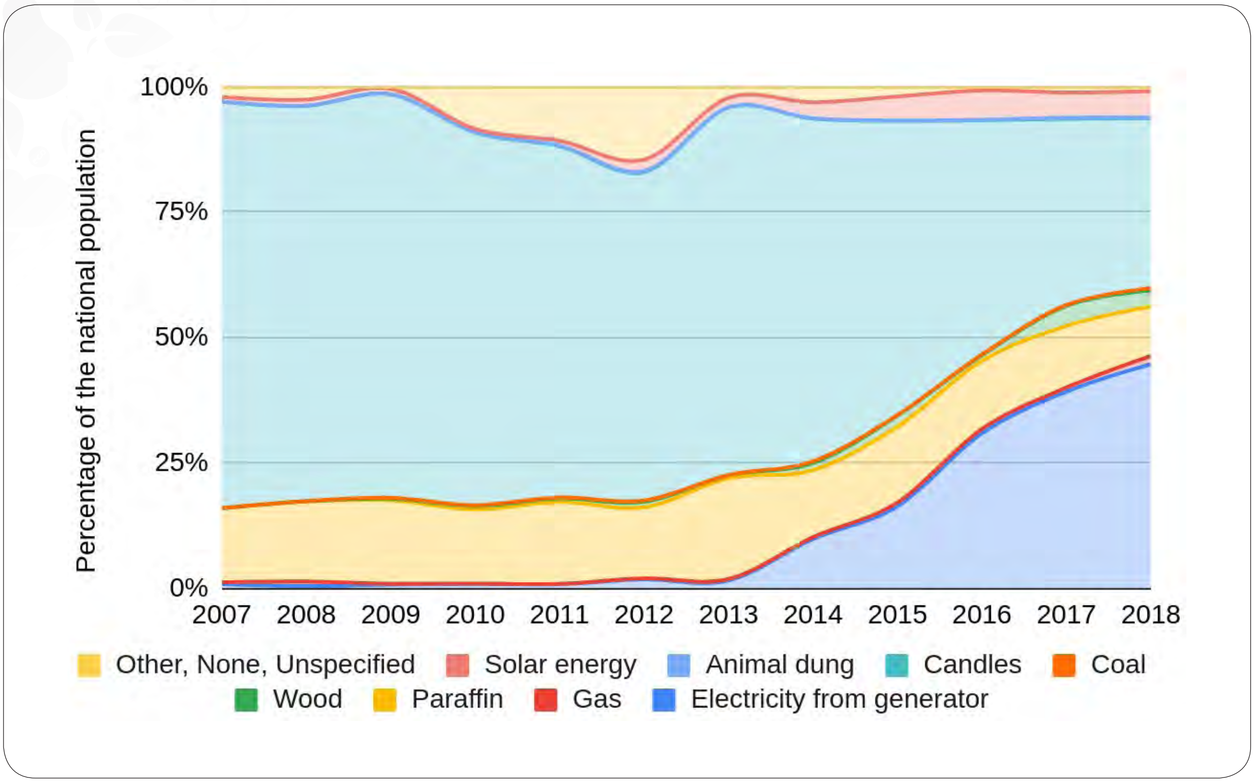

Figure 2.15.2: Percentage of the population using each fuel source as their main source of energy for lighting, excluding the share of the population that use electricity from the national grid as their main source of energy for lighting.

Analysis

The national electricity grid supplies more people with lighting each year. In contrast, the use of candles has declined each year. More than 10% of the population relied on candles for lighting in 2009, compared with 3% in 2018. Paraffin use has also declined since peaking in 2009. The number of people generating their own electricity has grown steadily since 2013. The use of solar energy for lighting trebled from 2007 to 2018, although for a much smaller proportion of the population. Less than one in every 200 people in South Africa use solar energy for lighting. The use of wood fuel as the main source of lighting has also increased in recent years. Further investigation and evaluation is needed to better understand the extent to which this is sustainable. The number of people using mainly gas for lighting varies from year-to-year. It is a matter of concern from a health perspective that the use of coal and animal dung persists. In 2018, more households were using coal for lighting than in any previous year reported here. More than 6.6 million people rely on the burning of animal dung, probably for cooking, for light.

Data

Table 2.15.1: Main energy sources for lighting, by the number of the population, in 1000s.

	Electricity from mains	Electricity from generator	Gas	Paraffin	Wood	Coal	Candles	Animal dung	Solar energy	Other None Unspecified
2007	40 278 679	69 627	30 189	1 263 365			6 934 255		79 271	173 341
2008	40 877 148	35 120	78 606	1 377 622			6 786 590		105 526	218 658
2009	41 816 199	59 616	11 672	1 389 549	27 465	14 152	6 710 510	0	91 153	31 985
2010	43 360 883	63 465	4 117	1 094 606	50 940	10 017	5 504 281	9 062	44 802	621 643
2011	44 770 957	54 848	1 347	1 108 684	46 460	14 855	4 744 975	9 493	63 821	728 927
2012	45 293 653	119 574	13 701	980 519	75 428	16 629	4 525 907	15 120	156 109	1 003 172
2013	47 824 644	79 364	15 127	1 061 638	32 517	871	3 873 656	0	101 458	115 112
2014	49 098 379	471 108	16 468	642 834	66 745	17 522	3 281 176	2 552	153 796	147 966
2015	49 449 372	865 379	39 312	801 753	118 460	5 847	3 110 987	3 496	254 096	101 789
2016	50 264 038	1 654 696	46 116	727 095	61 365	7 517	2 503 066	4 568	313 393	38 086
2017	51 155 780	2 103 267	43 247	659 688	215 431	9 351	1 992 627	12 547	269 145	60 865
2018	52 312 526	2 299 504	83 871	507 105	166 463	22 366	1 743 236	6 696	271 618	44 427

Data notes

The data are person weighted. It is not clear what is included in the data category 'Other', 'Unspecified', and these categories are summed with data for 'None'.

Data sources

Statistics South Africa. General Household Survey 2007-2018. Statistics South Africa, SuperWEB.

Indicator status and recommendations for the way forward

Tier 1

ANALYSIS AND REFLECTION ON INDICATORS IN THE ENERGY TRANSITION NARRATIVE

There are several interesting trends in overall GHG emissions by sector in Indicator 2.1. Overall emissions have remained relatively stable since 2010, with a slight decline in energy emissions. Not only is this driven by lower economic growth rates, but also by a structural change in the economy, as is illustrated by the evolution of South Africa's emissions intensity, in Indicator 1.2. In terms of South Africa's international emissions targets under the UNFCCC (Cancun 2010) and contained in its current NDC, South Africa's emissions are currently far lower than anticipated in previous studies (for instance, the then Department of Environment's Mitigation Potential Analysis of 2014). In Indicator 2.2, it is evident that South Africa's GHG emissions per capita are around 40% above the world average, on a par with lower-carbon developed economies and major developing economies such as China, but above most developing economies. Since 2010, emissions per capita have declined slightly – the South African population has grown, but GHG emissions have not.

Energy-related emissions constitute the majority of South Africa's emissions (around 80% since 2000). Indicator 2.3 disaggregates these into sectors – of these, energy industries constitute the majority (67% of energy emissions in 2015), primarily from electricity and liquid fuels production, followed by transport (13%) and industry (8%). While transport emissions have grown consistently since 2000, emissions from energy industries and industry grew consistently to 2010 but have declined slightly since then. Energy emissions as a whole have declined slightly since 2010 after significant growth since 2000.

Indicator 2.4 provides insight into the drivers for GHG emissions in the energy sector, portraying primary energy use in the South African economy. Although the data contains some anomalies which are not easy to explain (for instance, fluctuations in primary energy from renewable energy sources), energy use patterns tell a similar story – continuing dominance by fossil fuels, especially coal, and stabilisation of fossil fuel use from around 2010. Indicator 2.5 provides a level and trend for the physical intensity of GHG emissions per unit of primary energy, indicating that there has been only a very slight decline from 2000 to 2015. A more marked decline should result from the increased investment in renewable energy contemplated in IRP2019, but the REIPPPP as implemented up to 2015 was not large enough to make a significant difference.

Indicator 2.6 provides more insight into the technology mix which produces South Africa's electricity, which is still dominated by coal power. The decline in output since 2010 is largely a decline in coal-fired generation. This is also reflected in Indicator 2.7, which reflects a decline in the water intensity of electricity production, which matches the decline in coal-fired electricity generation.

Indicator 2.7.1 provides trends for air pollution in the country's three national air pollution Priority Areas. These areas have relatively high levels of energy-related activities, including among others mining and fuels processing, electricity production and energy combustion for industry and transport. It is anticipated that decarbonisation will bring about changes to energy-related activities, especially in electricity production and industry, that will in turn have an impact on the release of pollution into the atmosphere. Trends for this indicator should be looked at alongside Indicators 2.3, 2.4 and 2.6.

Indicators 2.8 to 2.12 provide more insight into emissions in the transport sector, which have grown steadily from 2000 to 2015. As can be seen from Indicator 2.9, the bulk of these emissions are from road transport, and per capita transport emissions have stabilised since 2008. Fuel use in the transport sector is overwhelmingly dominated by liquid fuels (Indicator 2.8). This can be expected to change with the anticipated electrification of transport in the 2020s. Indicators 2.10 (GHG emissions from local, as opposed to international, aviation) and 2.11, the rate of car ownership, indicate a growing middle class who are flying and driving private vehicles more. Indicator 2.12 indicates, by comparison to some other countries, the extremely low market penetration of electric vehicles so far in South Africa.

Indicator 2.13, the GHG intensity of the industrial sector (including mining, manufacturing and construction, but excluding electricity), has declined steadily since 2004, indicating a structural shift in the economy. This indicator excludes the indirect emissions from electricity used in these sectors.

Finally, Indicator 2.14 and 2.15 provide critical trends for the provision of key energy services to South African households. Electrification rates, indicated best by the number of people using electricity for lighting, have stalled since 2015 and the use of generators is also a result of load- shedding over the last few years.

Since the energy transition raises key policy questions which may not have been addressed before, several other indicators, for which no data is currently available, would also be useful for tracking changes in the energy system and associated relevant social, economic and environmental indicators. These include the GHG intensity of liquid fuels production, which is a considerable supply-side source of emissions in South Africa; investment in new renewable energy capacity, which should include renewable energy generated on-site, for which there is currently no reliable data; energy-related air pollution, which should decline as fossil fuel use declines; the GHG intensity of transport, measured in actual services delivered (GHG per passenger km and GHG per ton km); and the GHG intensity of cement and iron and steel production. All of these will require the development of more detailed data sources.

Other key areas for future development include more detailed measurements of the health impact of air pollution, including ambient and indoor air pollution; specific indicators for energy efficiency in industry, buildings and transport; and social and economic aspects of the energy transition, including just transition-related data on employment and economic development in the current and future energy sectors.

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THEMATIC AREA

NARRATIVE 3

WATER AND CLIMATE CHANGE

Contents

Figures and Tables

INTRODUCTION TO THE WATER AND CLIMATE CHANGE NARRATIVE

Investing in the water infrastructure (in terms of both management and providing services) is critical for the eradication of poverty and is a necessary condition for enabling sustained economic growth (Sanctuary and Tropp, 2007). Moreover, it enables the provision of a sustainable healthcare system (through the reduction of waterborne diseases) and improved well-being and social cohesion. The poor gain directly from improved access to basic water and sanitation services through improved health, prevented health care costs, personal safety and time saved, thereby reducing their vulnerability to a changing climate.

South Africa is, generally, a water-scarce country and climate change poses significant threats to water security. It is one of the driest countries in the world, with low and highly variable rainfall, erratic run-off and high evaporation. More than 60% of river flow arises from only 20% of the land area, requiring large-scale inter-basin transfers. It has been projected that rainfall (which drives water supply) will reduce over the western parts of the country and become more erratic, therefore the whole country will likely experience increased incidences of prolonged dry spells (likely resulting in droughts) (DEA, 2018) and intense rainfall events (likely resulting in flooding) (Abiodun *et al.*, 2017).

The state of catchment areas, the areas where water is collected through run-off into creeks, rivers and lakes, or into the groundwater system, is essential for the state of freshwater resources. Ensuring the protection of existing freshwater catchments is therefore important in ensuring the long-term sustainability of water supply into a potentially increasingly water scarce future. Climate change may further exacerbate threats to water quality through increased sedimentation resulting from erratic rainfall or salt-water intrusion into fresh-water resources in coastal areas.

Water supply has become increasingly important for economic growth over the past three decades as surface water resources (72% of global supply) are rapidly approaching full utilisation (Cole *et al.*, 2018). This poses a challenge not just for household supply, but also for the economy. Sectors, industries and company operations have varying degrees of water- usage and water efficiency potential. Those with high water usage are thus particularly vulnerable to changing water access and supply, particularly those with low water efficiency potential or without the capacity to implement increased efficiency measures. With this, related jobs are also vulnerable. Globally, a total of 78% of jobs are water-dependent, including work in agriculture, mining and manufacturing.

Fresh water usage in sectors, industries and company operations are not the only water-related vulnerabilities of the economy. Marine and coastal areas are also vitally important for activities such as fisheries, and climate change related impacts on the oceans pose a risk to the blue economy (ocean resources and ecosystems). For instance, rising sea surface temperatures, illustrated in Indicator 0.4, threaten the diversity and distribution of marine species (Tittensor *et al.*, 2010). This effect is compounded by the potential for ocean acidification as a result of increased CO_2 uptake into the ocean. Particularly pertinent to the South African context is the contribution played by upwelling on the west coast which brings nutrient-rich water to the surface and supports fish populations. This upwelling is driven by the direction and intensity of coastal winds, presented in Indicator 0.5, which may change under a changing climate.

The demand for water is expected to increase in future, as the economy grows and population increases. This will also mean that the competition for water across different sectors will be increased, highlighting the need to rigorously monitor withdrawals from the water system versus supply capacity. New water-use efficiency strategies must also be developed, including reducing water that is lost through leakages in supply infrastructure. This relates to the technical expertise of various tiers of government, as well as the financial management capacity of the complex set of actors involved in the water supply chain.

Strategic, long-term water resource management includes diversification of water resources, with reduced dependence on surface water contributing to the long-term sustainability of water supply. Different settings around the country will likely require different diversification approaches, and may include groundwater recharge, stormwater catchment and wastewater.

3.1 INDICATOR 3.1: NATIONAL DROUGHT INDEX

Indicator definition

The frequency and extent of meteorological drought across the primary Water Management Areas (WMA) through quantification of annual (12-month) Standardised Precipitation Evaporation Index (SPEI) accumulated moisture deficit.

Indicator rationale

ASouth Africa is a water-scarce country where water supply, which is central to the economy, is rapidly approaching full utilisation, and where a large proportion of the population still do not have equitable access. With projections indicating that rainfall, which drives water supply, may become more erratic and increase incidences of prolonged dry periods, it is important to track the occurrence of drought conditions across the country.

The aggregation to WMAs is more useful than provinces because WMAs are managed as units from a water resources perspective. Aggregation to agricultural areas is possible but becomes extremely complex when considering multiple crops and commercial versus subsistence agricultural areas. SPEI is a widely used meteorological (climate) drought indicator because it captures the effect of rainfall deficits as well as evaporation variations which are strongly linked to temperature. This means that moisture deficit can be driven by high temperatures as well as rainfall deficits. With increasing temperatures an extremely high likelihood into the future, it is important to capture the impact of higher temperatures, not just rainfall changes, on moisture availability.

Data visualisation

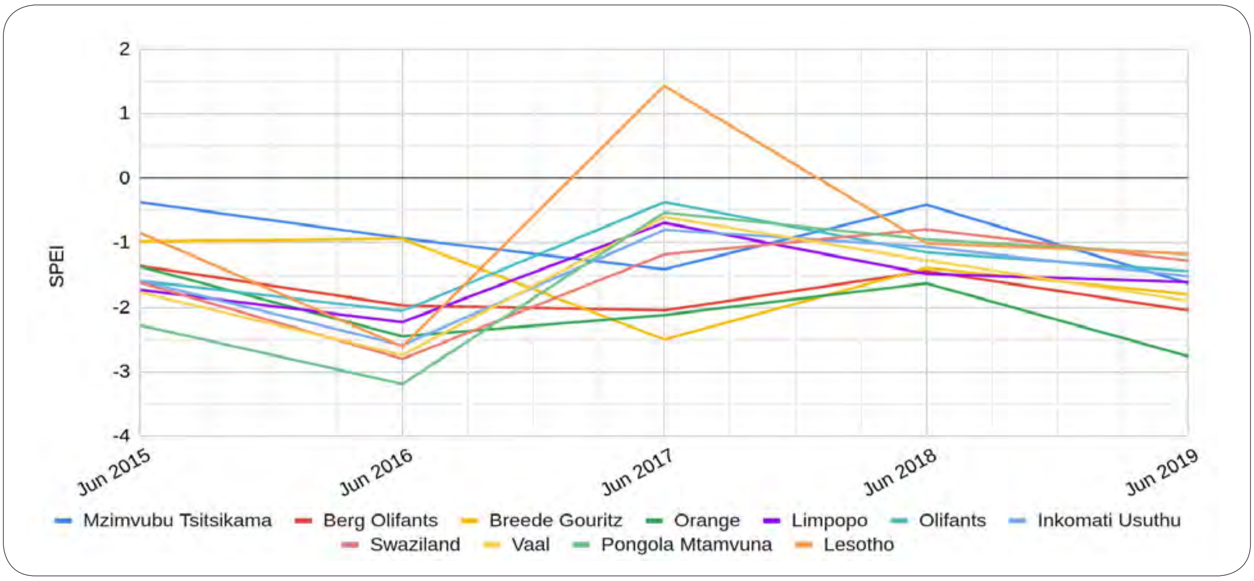


Figure 3.1.1: Standardised Precipitation-Evapotranspiration Index over primary Water Management Areas. SPEI less than 1 indicates drought.

Analysis

The past five years have been characterised by widespread and intense drought across all major WMAs relative to the long-term average. This is likely related to a strong El Niño (2015/2016, 2018/2019) resulting in low rainfall and higher temperatures (and evaporation). While there would certainly be a contribution of higher temperatures attributed to anthropogenic climate change (evidenced by long-term increasing temperature trends across the country) isolating this from the role of ENSO is challenging.

Data

Table 3.1.1: Standardised Precipitation-Evapotranspiration Index over primary Water Management Areas. SPEI less than 1 indicates drought.

	6/1/2015	6/1/2016	6/1/2017	6/1/2018	6/1/2019
Mzimvubu Tsitsikama	-0.37	-0.93	-1.41	-0.41	-1.63
Berg Olifants	-1.36	-1.97	-2.05	-1.44	-2.05
Breede Gouritz	-0.98	-0.94	-2.5	-1.39	-1.8
Orange	-1.37	-2.45	-2.12	-1.63	-2.76
Limpopo	-1.73	-2.23	-0.69	-1.48	-1.61
Olifants	-1.59	-2.06	-0.37	-1.15	-1.44
Inkomati Usuthu	-1.59	-2.59	-0.8	-1.06	-1.52
Swaziland	-1.62	-2.8	-1.18	-0.79	-1.28
Vaal	-1.77	-2.74	-0.6	-1.27	-1.9
Pongola Mtamvuna	-2.28	-3.19	-0.53	-0.95	-1.18
Lesotho	-0.85	-2.61	1.43	-1.01	-1.17

Data notes

The SPEI data is based on global datasets and has been spatially aggregated to local Water Management Areas. The data is sourced from the CSIC (Spanish National Research Council) because it is complex to calculate SPEI consistently and CSIC have invested resources into constructing this dataset. Limitations are that it uses CRU observed rainfall and temperature which, while globally consistent, may not be the best rainfall and temperature data available for South Africa. However, for provincial and WMA scale analysis it is likely to be robust.

Data sources

CSIC Spanish National Research Council, Beguería, S., Latorre, B., Reig, F. and Vicente-Serrano, S. M., SPEI drought monitor. [Online] CSIC (Spanish National Research Council). Retrieved from https://spei.csic.es/map/maps.html

Indicator status and recommendations for the way forward

Tier 2

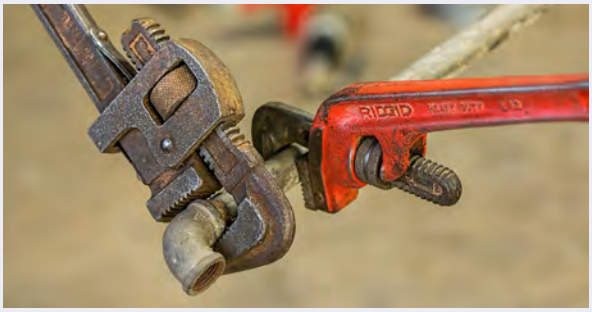
Comment: Alternative, local sources of primary data (rainfall, temperature and evaporation) that are better representative of WMA will need to be applied in future reporting through collaboration with the South African Weather Service (SAWS) and the Agricultural Research Council (ARC).

INDICATOR 3.2: HEAVILY WATER-DEPENDENT JOBS

3.2

Indicator definition

Total number of jobs relative to water use, focusing on heavily water-dependent industry sub-sectors.



Indicator rationale

Water resources are under pressure as a result of population growth, water-intensive economic and personal consumption, pollution and changing climate. These pressures create risk for people whose livelihoods rely on heavily water-dependent businesses. Monitoring the change in sectoral water usage relative to jobs makes it possible to identify any encouraging or concerning changes in water usage or employment numbers for sectors that are vulnerable to water scarcity, while at the same time important for employment.

Data visualisation

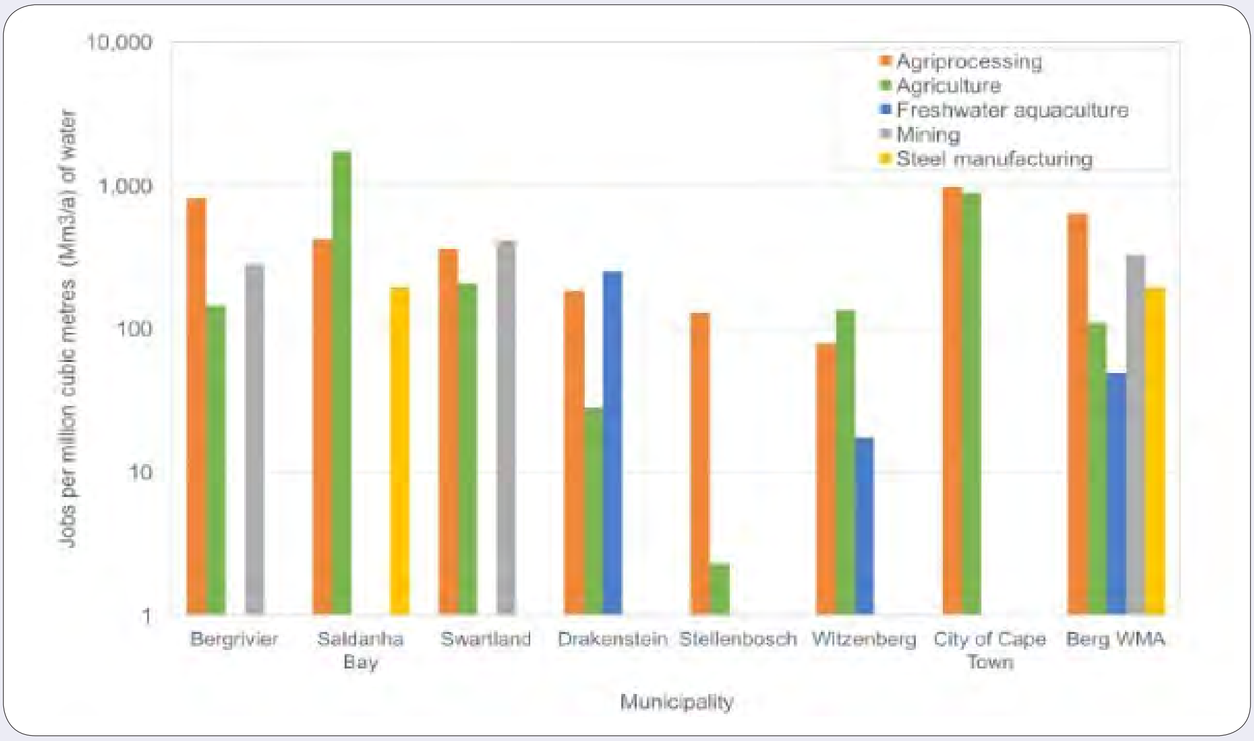


Figure 3.2.1: Estimated total jobs per million cubic metres of water used for heavily water- dependent sectors per municipality in the Berg Water Management Area in 2011 (noting that steel is missing) (Source: Cole *et al.*, 2018).

Analysis

Jobs and income vary significantly across municipalities and sectors but, overall, agri-processing produces the most jobs per volume of water used, at 633 jobs/Mm^3, followed by mining (326 jobs/Mm^3), steel processing (195 jobs/Mm^3), agriculture (109 jobs/Mm^3) and aquaculture (49 jobs/Mm^3). In the context of a changing climate and other pressures influencing water availability, the long-term feasibility of water-intensive sectors with few jobs, such as aquaculture, may require further investigation.

Data notes

Note: The graph and analysis is based on the Berg WMA case study only, and numbers are from 2011 only. This is thus a case study example and is not nationally representative.

Data

Table 3.2.1: Estimated total jobs per million cubic metres of water used for heavily water- dependent sectors per municipality in the Berg Water Management Area in 2011 (noting that steel is missing) (Source: Cole *et al.*, 2018).

Municipality	Agriculture	Freshwater Aquaculture	Agriprocessing	Mining	Total
Bergriver	145		807	280	114
Saldanha Bay	1 712		421		786
Swartland	205		356	408	234
Drakenstein	28	249	183		41
Stellenbosch	2		130		7
Witzenberg	134	17	79		112
City of Cape Town	887		965		932
Total Berg WMA	109	49	633	326	177

Data notes

Cole, M.J., Bailey, R.M., Cullis, J.D. and New, M.G., 2018. Water for sustainable development in the Berg Water Management Area, South Africa. South African Journal of Science, 114(3-4), pp.1-10.

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Department of Water and Sanitation, Water Authorisation Registration and Management System (WARMS) website. Retrieved from http://www.dwa.gov.za/Projects/WARMS/default.aspx

Indicator status and recommendations for the way forward

Tier 3

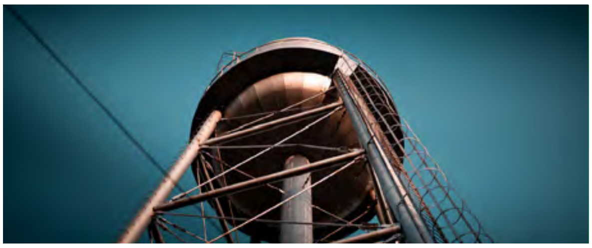
Currently showing: Once-off study of Berg WMA (Cole *et al.*, 2018)

Required: Access to WARMS data, and calculations thereof for each local municipality. National calculations for water-intensive sectors, conducted at regular intervals, are required to get the national picture over time.

INDICATOR 3.3: PRESERVATION OF WATER

Indicator definition

The percentage of each Water Management Area that is protected.



Indicator rationale

The state of catchment areas, the areas where water is collected through run-off into creeks,rivers and lakes, or into the groundwater system, is essential for the state of freshwater resources. Water resources are under pressure as a result of population growth, water-intensive economic and personal consumption, pollution and changing climate. Ensuring the protection of existing freshwater catchments, represented here through Water Management Areas (WMAs), is therefore important in ensuring the long-term sustainability of water supply.

Data visualisation

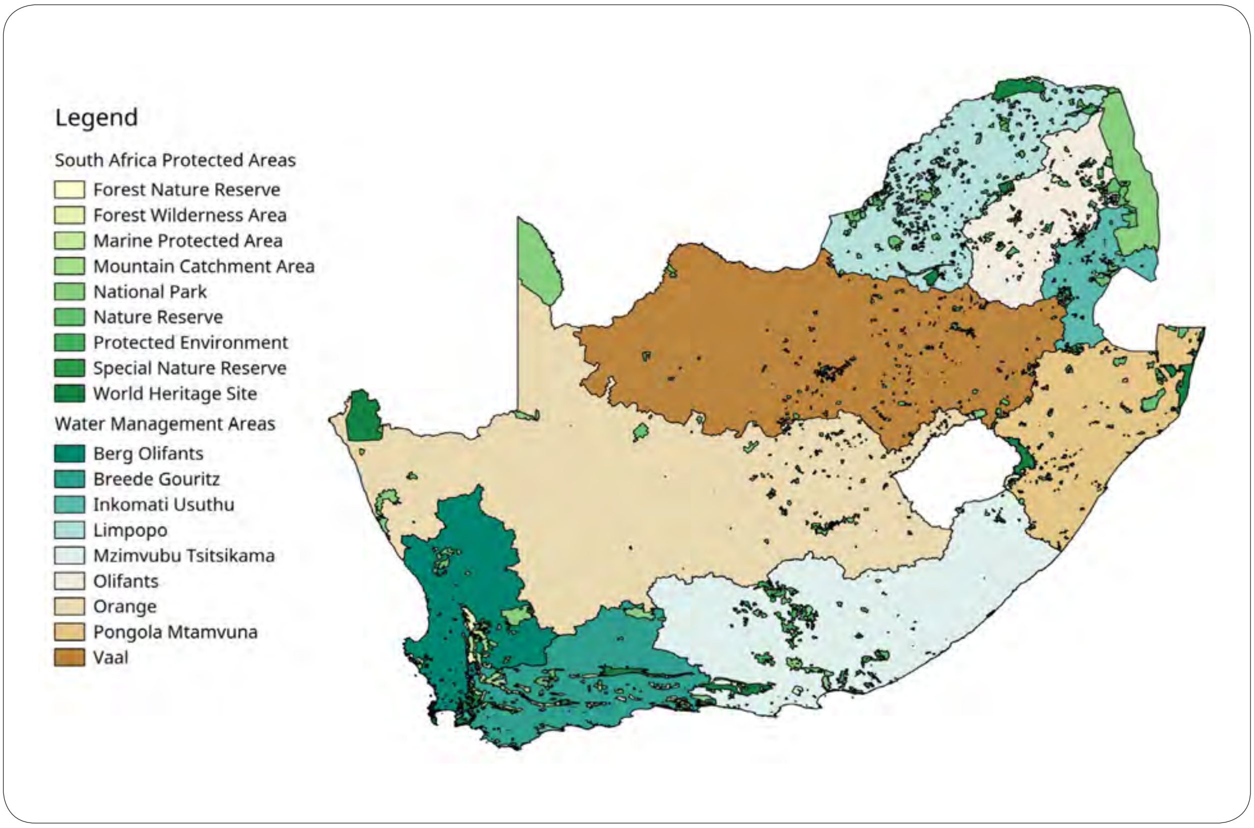


Figure 3.3.1: Protected Areas and Water Management Areas in South Africa.

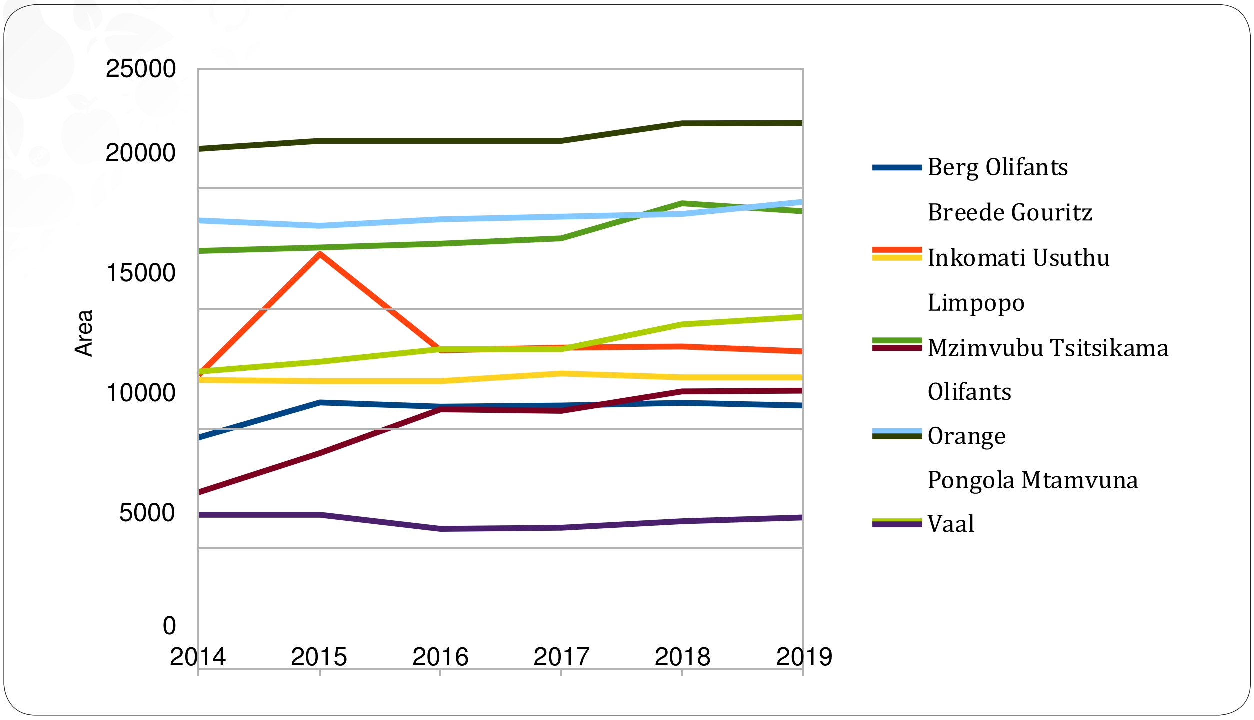


Figure 3.3.2: Size of Protected Areas per Water Management Area in South Africa (km²).

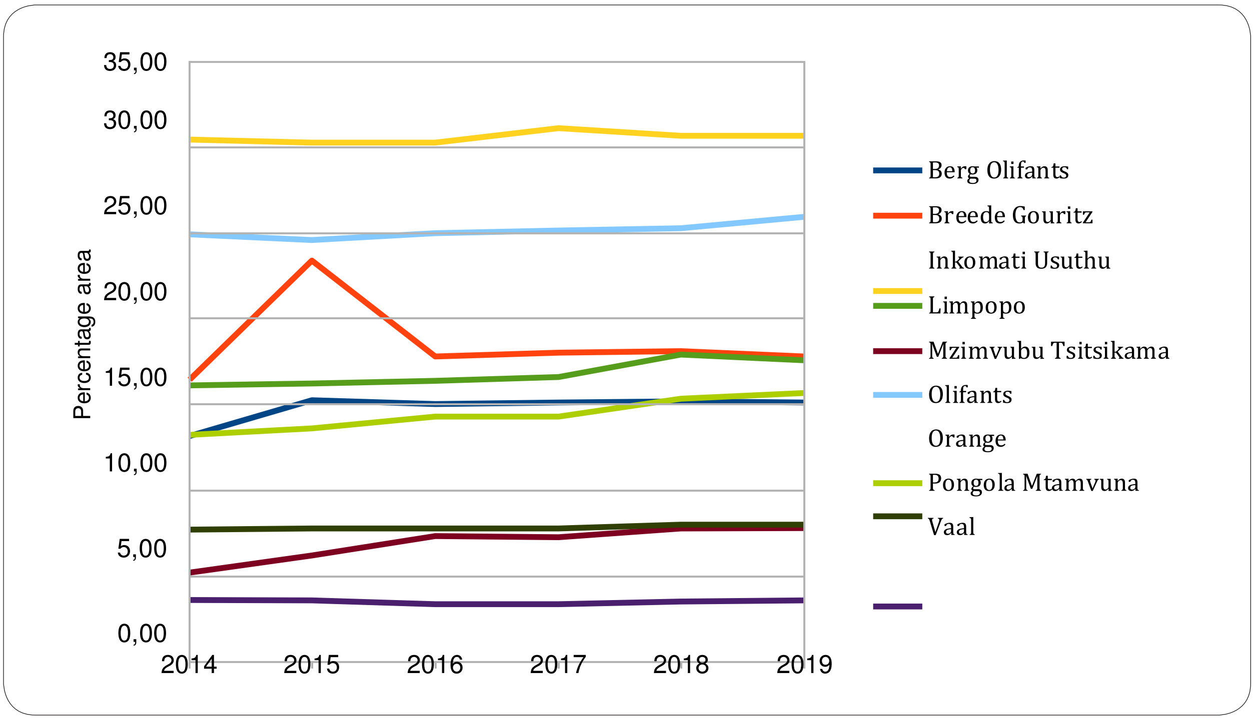


Figure 3.3.3: Protected Areas as a percent of each Water Management Area in South Africa.

Analysis

Just less that 10% of South Africa is classified as Protected Area. South Africa is divided into nine Water Management Areas and the distribution of protected areas varies greatly between these. Generally speaking, the larger WMA (Orange, Vaal and Mzimvubu Tsitsikama) have a smaller proportion of their catchments designated as protected areas. The Olifants and the Inkomati Usuthu Water Management Areas have a relatively large proportion of their area designated as protected (24% and 29% respectively), but this is primarily due to the Kruger National Park being located in the lower reaches of these two catchments. The remaining Water Management Areas (Berg Olifants, Breede Gouritz, Limpopo and Pongola Mtamvuna) may not have such a large proportion of their catchment designated as protected areas, however a significant proportion of the protected areas are within the upper mountain catchment, or coastal areas, which are important for water provision and water quality.

There has been little change in the location and extent of protected areas since 2014, with all but the Vaal Water Management Areas showing a slight increase (less than 3%) in protected areas.

Data

Table 3.3.1: Size of Water Management Areas in South Africa (km^2).

	Area (km^2)
Berg Olifants	70 208
Breede Gouritz	72 297
Inkomat i Usuthu	36 546
Limpopo	109 496
Mzimvubu Tsitsikama	163 161
Olifants	73 628
Orange	354 776
Pongola Mtamvuna	93 433
Vaal	246 214

Table 3.3.2: Size of Protected Areas per Water Management Area in South Africa (km^2).

	2014	2015	2016	2017	2018	2019
Berg Olifants	8 130	9 593	9 413	9 484	9 484	9 470
Breede Gouritz	10 742	10 742	11 747	11 882	11 944	11 717
Inkomat i Usuthu	10 548	10 487	10 487	10 796	10 644	10 642
Limpopo	15 902	16 055	16 203	16 436	17 880	17 527
Mzimvubu Tsitsikama	5 850	7 507	9 289	9 224	10 047	10 089
Olifants	17 185	16 947	17 207	17 345	17 442	17 946
Orange	21 657	22 005	22 005	22 003	22 715	22 713
Pongola Mtamvuna	10 878	11 259	11 830	11 830	12 860	13 161
Vaal	4 910	4 903	4 324	4 402	4 628	4 789

Table 3.3.3: Protected Areas as a percent of each Water Management Area in South Africa.

	2014	2015	2016	2017	2018	2019
Berg Olifants	11,58	13,66	13,41	13,51	13,60	13,49
Breede Gouritz	14,86	21,82	16,25	16,43	16,52	16,21
Inkomat i Usuthu	28,86	28,70	28,70	29,54	29,12	29,12
Limpopo	14,52	14,66	14,80	15,01	16,33	16,01
Mzimvubu Tsitsikama	3,59	4,60	5,69	5,65	6,16	6,18
Olifants	23,34	23,02	23,37	23,56	23,69	24,37
Orange	6,10	6,20	6,20	6,20	6,40	6,40
Pongola Mtamvuna	11,64	12,05	12,66	12,66	14,09	14,09
Vaal	1,99	1,99	1,76	1,79	1,88	1,95

Data notes

This indicator just uses total area within protected areas but does not consider the climate or location of these protected areas. For example, the largest protected areas within the Orange Water Management Area are the Kgalagadi Transfrontier Park and the Richtersveld National Park which are both located in the very dry regions in the lower parts of the catchment. This is in contrast to the Breede Gouritz Water Management Area where most protected areas are located within upper mountain catchments, which are critical to the preservation of water.

The 2014 and 2015 datasets included some Conservation Areas within the Protected Areas shapefiles. These were removed. All shapefiles had errors in their geometry which were corrected before the analysis was undertaken.

Data sources

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Government Gazette, Water Management Areas. 16 September 2016 (No. 40279). Retrieved from https://www.greengazette.co.za/documents/

Indicator status and recommendations for the way forward

Tier 1

ANALYSIS AND REFLECTION

South Africa is a water-scarce country where water supply, which is central to the economy, is rapidly approaching full utilisation, and where a great proportion of the population still do not have equitable access.

Over the past five years, South Africa has been characterised by nationwide and intense droughts, as illustrated in Indicator 3.1 and in the urban drought Indicator 5.3, as well as through the below normal rainfall and increasing temperatures reported on in Indicator 0.2 and 0.1 respectively. This has led to varying degrees of crisis for water supply across the country over the past few years.

Water usage, and how it links into the economy and job creation is another important part of the water picture. Attempts to show the vulnerability of water-intense industries, and their linkages to employment, are only in the beginning stages here. The case study in Indicator 3.2 presents the total number of jobs relative to water use for heavily water-dependent industry sub-sectors in the Berg WMA. This indicates how relationships between industry sub-sectors and job creation varies greatly, with agri-processing producing the most jobs and aquaculture the least jobs per million cubic metres of water. Similar tracking at a national scale could enable the identification of encouraging and concerning changes, and support the development of interventions that ensure job retention in the face of potentially dwindling water supply.

The state of a catchment area influences the quality of water collected through run-off and groundwater infiltration, and hence Indicator 3.3 looks at the percentage of each Water Management Area that is protected. With the exception of the Olifants and the Inkomati Usuthu, most WMAs do not have a large proportion of their catchment designated as protected areas, with no significant change in protected areas observed in any of the WMAs since 2014.

While this narrative largely focuses on freshwater resources, it also makes a connection with the state of saltwater resources, as it is an important factor for sectors such as fisheries. The lack of existing datasets on ocean acidification is a large gap. It may have a significant impact on marine resources so should be monitored. Filling such data gaps will provide a more comprehensive picture of the water sector into the future.

This narrative set out to bring water and climate change issues closer to the broader national goals around job creation, economic growth, equity, development and service delivery. In so doing it has moved away from the environmental linkages, and aspects related to biodiversity and ecosystems. As per the input from stakeholders, future iterations of this narrative and related indicators may need to see the inclusion of indicators that speak to these aspects, including ecological reserves and ecological infrastructure. As such, future iterations may see this chapter move into a 'water for life' narrative, rather than a 'water for development' narrative.

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THEMATIC AREA

NARRATIVE 4

SOCIAL VULNERABILITY

Contents

Figures and Tables

INTRODUCTION TO THE SOCIAL VULNERABILITY NARRATIVE

Social vulnerability refers to the inherent vulnerability of the human system in focus, independent of external hazards or stressors (Brooks, 2003). In other words, it speaks to the characteristics of the society that influence its capacity to prepare for, respond to, and recover from climate-related events, both chronic and extreme. Determinants of social vulnerability typically include socio-economic status (e.g. poverty, inequality), demographic characteristics (e.g. age, gender, race), access to basic services (e.g. healthcare, education, sanitation and waste removal, water, electricity, and arguably the internet), access to resources (e.g. food, income) as well as special needs groups (e.g. disabled) (Brooks, 2003; Cutter *et al.*, 2009, Otto *et al.*, 2017). As acknowledged in the IPCC's Fifth Assessment Report (2014) "Development challenges, such as gender inequality and low levels of education, and other differences among communities in age, race and ethnicity, socioeconomic status, and governance can influence vulnerability to climate change impacts in complex ways". The narrative therefore seeks to capture key social vulnerability elements that amplify the national risk profile in terms of climate hazards whereby disadvantaged groups are typically more exposed to the adverse effects of climate change, which in turn increases the potential damage caused by climate change related disasters (NDP, 2012). Such a trend has the potential to become a vicious cycle, where damage caused further undermines resilience and already limited adaptive capacity.

One of the most unequal societies in the world, South Africa has high poverty levels, low economic growth and a burgeoning unemployment problem concentrated amongst the youth. The narrative opens by picking up on these 'triple challenge' priorities of inequality, poverty and unemployment as described in the National Development Plan, which are presented at a provincial scale and disaggregated in terms of race, education level and age (NDP, 2012). Recognising that there are a suite of related parameters one could disaggregate, the elements of the 'triple challenge' by race, education level, and age have been selected due to the key role they play in driving inequality, poverty and unemployment respectively. Placing these three indicators up front not only recognises the fundamental role they play in undermining adaptive capacity, but also provides a cross-cutting trackable 'base layer' that can be used in reference to other narratives in future iterations of this indicator suite.

In response to such high levels of social vulnerability it is imperative that social protection is in place to sufficiently buffer disadvantaged groups in the face of the impacts of climate change. This includes tracking the provision of social grants that provide a basic standard of living for those unable to generate income, as well as the provision of basic services. This is followed by tracking the incidences of climate-related disasters across all provinces by disaster type. Recognising that not all climate-related incidences are climate change related, this does however provide a proxy of climate vulnerability and it is envisaged that reporting on this item through the National Disaster Management Centre (NDMC) will become more detailed, thus providing improved applicability and resolution. A case study of temperature-related risk and mortality is included as an example of outputs that could be generated on an ongoing basis using the District Health reporting system. A focus on malaria follows as one of the key directly climate-respondent health issues faced in South Africa. This closes an initial 'snap shot' of social vulnerability related indicators and proxies that have relevance to climate change. It is hoped that this will provide sufficient 'ground' for future iterations to build upon.

INDICATOR 4.1: INEQUALITY

4.1

Indicator definition

Measure of inequality per province and population group, based on per capita income.

Indicator rationale

South Africa, one of the most unequal countries in the world, is characterised by high inequality in the demographic profile, unequal ownership of assets and income, unequal engagement in the labour market, as well as unequal access to basic services and social mobility (World Bank, 2018; StatsSA, 2019). The intersection of inequality and climate change creates a vicious cycle whereby an initial state of inequality manifests in disadvantaged groups with heightened exposure and susceptibility to the hazards and impacts of climate change (e.g. susceptible to flooding or wind damage due to living in an informal settlement in low-lying area). These groups have limited choices and resources to prepare for, cope with and respond to climate impacts (low adaptive capacity, resilience and coping capacity), and therefore suffer disproportionately resulting in greater levels of inequality (Islam and Winkel, 2017).

This indicator tracks inequality using the Gini coefficient and Palma ratio. The Palma ratio examines how income inequality manifests within sub-groups, in this case across population groups. It breaks up the share of income into the bottom 40%, middle 50% and top 10%. The bottom 40% and top 10% are of interest here.

Data visualisation

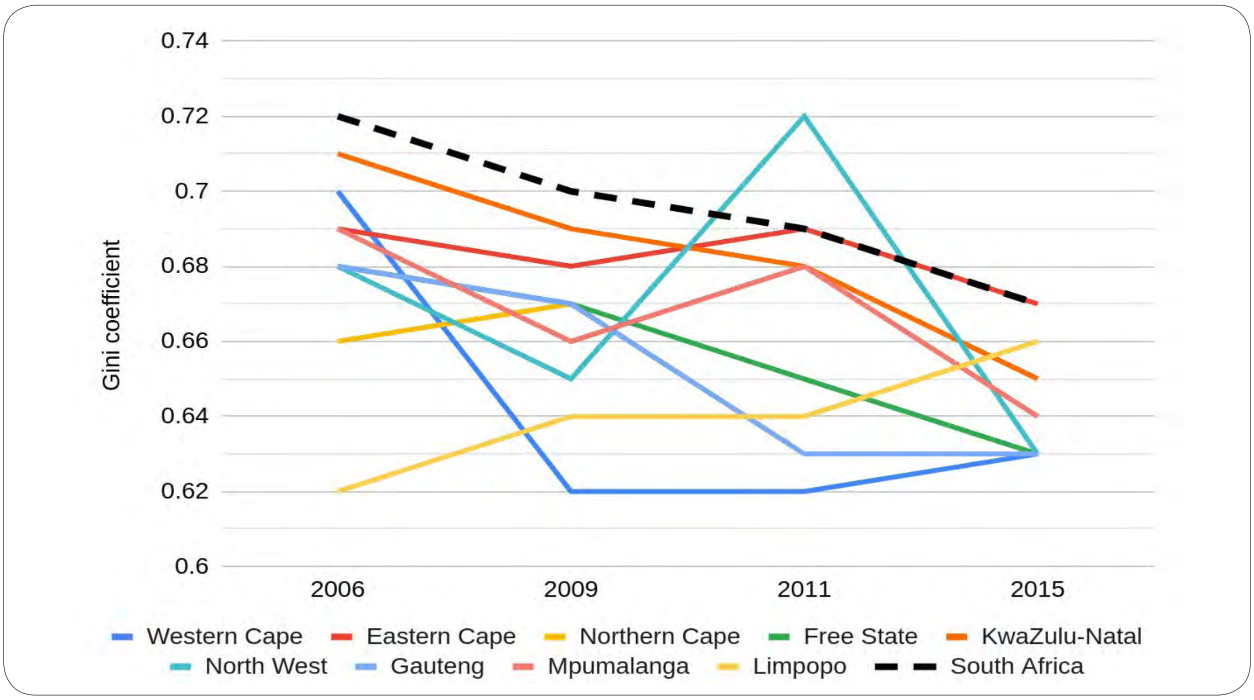

Figure 4.1.1: Provincial Gini coefficient based on per capita income.

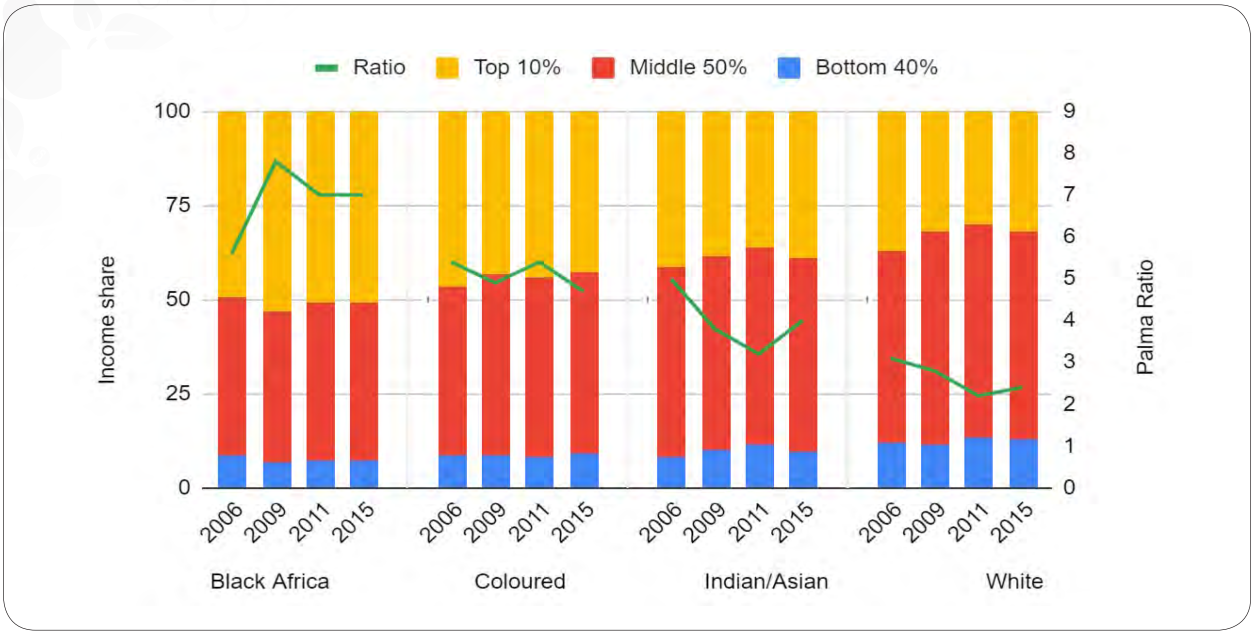

Figure 4.1.2: Income share (bars) and Palma ratio (line) based on per capita income / population group of household head.

Analysis

Although still considered extremely high by international standards, the national level of inequality has declined slightly over the period represented. At the provincial scale the spread is more concentrated mostly due to a reduction in inequality levels. KwaZulu-Natal and Free State provinces have both steadily declined. Provinces that have shown a decline, although not steady, include Eastern Cape, Mpumalanga and North West. The Western Cape, Gauteng and the Northern Cape have also decreased relative to the initial period but have shown either a rise in the last period (Western Cape) or a levelling out (Gauteng and Northern Cape). Limpopo is the only province with higher inequality levels in 2015 than in 2006. This is a significant counter-trend and reasons driving this need to be explored further.

The Palma ratio data represented shows that the black African population has the highest within -group inequality which increased significantly between 2006 and 2009 to 7.8, dropping slightly to 2011 and levelling out to 2015.

This saw the top 10% earning around 50% of the income and the bottom 40% earning a maximum of 9% and below. The Palma ratio for the coloured population started off in 2006 at a similar level to that of black Africans, but did not increase much from this point, zigzagging to end at a slightly lower level of 4.5 in 2015. The share of income of the top 10% amongst this group was lower than amongst black Africans, starting at 47% in 2006 and trending down to 43% in 2015, with the bottom 40% earning around 9% of the income share. In the Indian/Asian group, the ratio was lower and dropped quite significantly across the data period represented, with the top 10% earning just over 40% of the income share. This reduced to figures between 40% and 35% for the rest of the period, with the bottom 40% having around 10% share of the income. The white population group exhibits the lowest within group inequality with the top 10% earning just over 30% of the income, and the bottom 40% earning above 10% of the income share.

Data

Table 4.1.1: Provincial Gini coefficient based on per capita income.

	2006	2009	2011	2015
Western Cape	0,7	0,62	0,62	0,63
Eastern Cape	0,69	0,68	0,69	0,67
Northern Cape	0,66	0,67	0,63	0,63
Free State	0,68	0,67	0,65	0,63
KwaZulu-Natal	0,71	0,69	0,68	0,65
North West	0,68	0,65	0,72	0,63
Gauteng	0,68	0,67	0,63	0,63
Mpumalanga	0,69	0,66	0,68	0,64
Limpopo	0,62	0,64	0,64	0,66
South Africa	0,72	0,7	0,69	0,67

Table 4.1.2: Income share and Palma ratio based on per capita income / population group of household head.

		Black African	Coloured	Indian/Asian	White
2006	Bottom 40%	8.8%	8.7%	8.4%	12.1%
	Middle 50%	41.6%	44.7%	50.0%	50.9%
	Top 10%	49.6%	46.6%	41.6%	37.0%
	Ratio	5.6	5.4	5	3.1
2009	Bottom 40%	6.8%	8.8%	10.0%	11.5%
	Middle 50%	40.0%	48.0%	51.5%	56.7%
	Top 10%	53.2%	43.2%	38.5%	31.8%
	Ratio	7.8	4.9	3.8	2.8
2011	Bottom 40%	7.3%	83%	11.5%	13.4%
	Middle 50%	42.1%	47.3%	52.3%	56.7%
	Top 10%	50.6%	44.4%	36.2%	29.9%
	Ratio	7	5.4	3.2	2.2
2015	Bottom 40%	7.2%	9.0%	9.7%	13.0%
	Middle 50%	42.2%	48.4%	51.4%	55.2%
	Top 10%	50.6%	42.6%	38.9%	31.8%
	Ratio	7	4.7	4	2.4

Data notes

For Gini coefficient: 0 = completely equal society; 1 = highly unequal society

For Palma ratio: higher = more unequal; lower = greater parity

This data is drawn from a once-off special focus report which is based on data inputs sourced from data that are regularly collected and released officially by Stats SA. These include: Income and Expenditure Survey (IES); Living Conditions Survey (LCS); General Household Survey (GHS); and Quarterly Labour Force Survey (QLFS).

This indicator is based on household income data; however it is noted that in the South African context household expenditure data is more robust and better reported and therefore often used as a proxy for income data (Stats SA, 2019). Expenditure data is available for all the parameters used in this indicator.

Data sources

Statistics South Africa, 2019. Inequality Trends in South Africa: A multidimensional diagnostic of inequality. Retrieved from www.statssa.gov.za

Indicator status and recommendations for the way forward

Tier 1

INDICATOR 4.2: CLIMATE-RELATED DISASTERS

4.2

Indicator definition

The total number of climate-related disasters per type declared at a municipal scale, aggregated to a provincial scale.

Indicator rationale

Climate change hazards include increased temperatures and strong winds. These result in impacts such as floods, droughts, storms, coastal storm surges, increased fire risk and other storm-related impacts such as gale force winds and tornados. As the country is divided into summer and winter rainfall areas, it is useful to disaggregate climate incidences to a higher spatial resolution like provinces as depicted here. This allows for risk to weather- and climate-related incidences to be tracked provincially.

Data visualisation

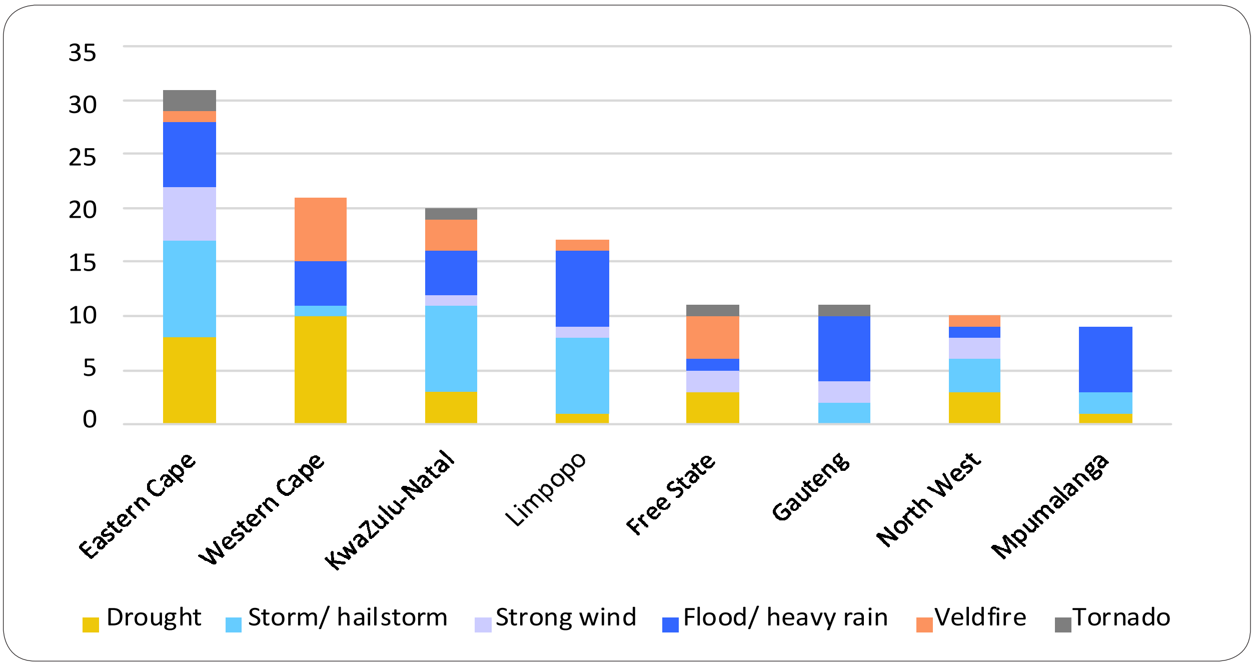

Figure 4.2.1: Count of climate-related disasters per province (2008-2019).

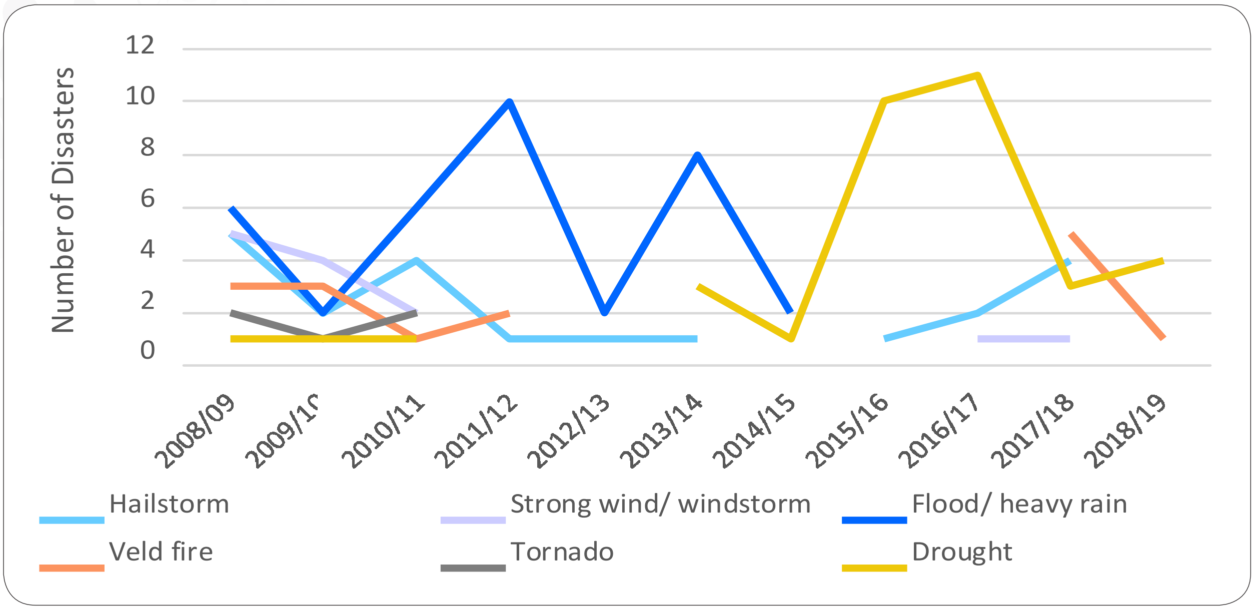

Figure 4.2.2: Total count of climate-related disasters in South Africa.

Analysis

There is a clear trend of wet period (floods/heavy rain) and dry period (drought) over the data period. Floods/ heavy rain show the highest incidences from 2008/2009 until 2013/2014, whereas incidences of droughts start increasing from 2013/2014. In 2016/2017, the Western Cape, Northern Cape and Eastern Cape provinces were classified as drought disaster areas, contributing to the highest incidences of droughts. The scarcity of water is devastating to the farming industry, economy and daily livelihoods.

Drought and floods/heavy rain are a threat to all provinces, with the exception of Gauteng for drought. The Western Cape and Eastern Cape have the highest incidences of drought. Storms are a major threat to the Eastern Cape, Limpopo and KwaZulu-Natal, with observed high incidences of storms. The Eastern Cape has experienced more climate-related impacts relative to other provinces, followed by KwaZulu-Natal with the second most impacts. Therefore, these provinces are vulnerable and require plans and measures to build resilience.

Data

Table 4.2.1: Number of climate-related disasters per province.

	Drought	Storm / hailstorm	Strong wind	Flood / heavy rain	Veldfire	Tornado
Eastern Cape	8	9	5	6	1	2
Western Cape	10	1		4	6	
Northern Cape	4			1		
North West	3	3	2	1	1	
Gauteng		2	2	6		1
Limpopo	1	7	1	7	1	
Mpumalanga	1	2		6		
Free State	3		2	1	4	1
KwaZulu-Natal	3	8	1	4	3	1

Table 4.2.2: Total count of climate-related disasters in South Africa from 2008/09 to 2018/19.

	Hailstorm	Strong wind / windstorm	Flood / heavy rain	Veldfire	Tornado	Drought
2008/09	5	5	6	3	2	1
2009/10	2	4	2	3	1	1
2010/11	4	2	6	2	2	1
2011/12	1		10	1		0
2012/13	1		2			0
2013/14	1	1	8			3
2014/15			2	2		1
2015/16	1		0			10
2016/17	2	1	5			11
2017/18	4	1	0	5		3
2018/19				1		4

Data notes

Data is also available from the NDMC incident database. Data is available in this database down to the local level, so reporting could take place at a higher resolution than is depicted here.

Data sources

National Disaster Management Centre (NDMC), (2008-2019). *Annual Reports*. Retrieved from http://www.ndmc.gov.za/Pages/annualreports.aspx

Indicator status and recommendations for the way forward

Tier I

Comment: Data has been harvested from both the NDMC Annual Reports as well as the NDMC Historical Declared States of Disaster database. This data is supplied to the NDMC by the local, district or provincial level disaster management authority and is not always completed for all fields. This indicator can therefore be improved as gains are realised in response to efforts to improve the reporting.

INDICATOR 4.3: TEMPERATURE AND MORTALITY

4.3

Indicator definition

Relative risk of mortality related to temperature.

Indicator rationale

Long-term climate change due to anthropogenic influence has primarily been evidenced by increasing global air temperatures since the early 20th Century. Temperature increases, including the resultant increase in frequency of extremes (hot days, heat spells and cold snaps) impacts directly on people's health through heat stress and exposure to cold. As evidenced in Indicator 0.1, the number of hot days per year has more than doubled in the past two decades across all provinces. Given the relatively high levels of social vulnerability explored in this narrative, significant numbers of the population live in conditions that expose them disproportionately to extreme weather events.

Understanding and tracking the extent to which temperature extremes negatively impact health is key to designing and implementing effective adaptation.

Data visualisation

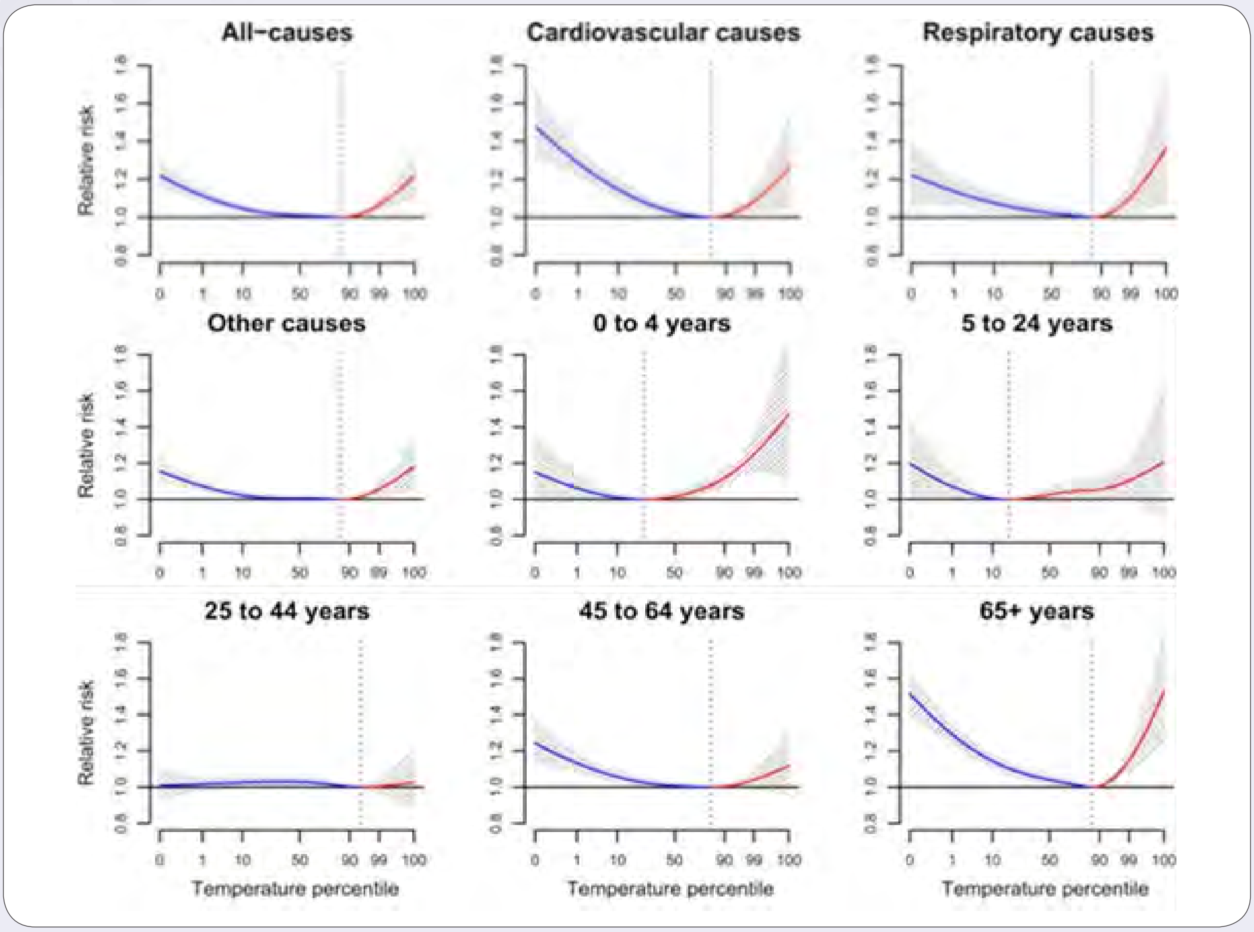

Figure 4.3.1: Risks of mortality associated with maximum daily temperature for different cause and age groups. Dotted vertical lines show the minimum mortality temperature percentile (Source: Scovronick *et al.*, 2018).

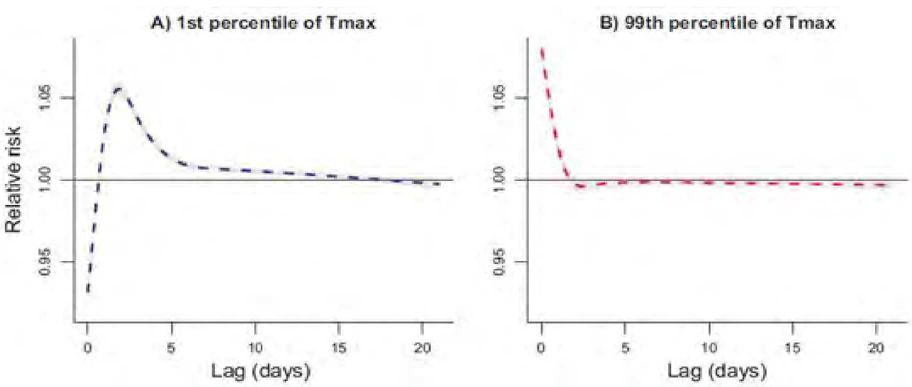

Figure 4.3.2: Relative risk of mortality over the 21-day lag period at the 1st (cold) and 99th (heat) percentile of the distribution of daily maximum temperatures (Tmax) relative to the minimum mortality temperature (Source: Scovronick *et al.*, 2018).

Analysis

The response curves display results for the overall cumulative exposure by age and cause of death groupings. All except the 25-44 years age group experienced elevated risk of mortality in the face of temperature extremes. Noteworthy is high risk, particularly to heat but to a lesser extent to cold, in the 0-4 years age group. This is similar in the 65 years and above age group, who are also susceptible to increased risk to heat and cold. These two age groups appear to be the most vulnerable to temperature extremes. However, what is also evident is the increased risk, particularly to cold and a lesser degree to heat, of those suffering from cardiovascular illness. The opposite appears to be the case for those suffering from respiratory illnesses, with an elevated risk to heat, and a lesser degree cold.

The study also documents lag times where the relative risk of mortality due to extreme cold or heat is elevated – in other words, the time after the extreme event where the negative health impact manifests. Noteworthy is that the elevated risk to cold has a longer lag time than the elevated risk of mortality due to extreme heat. This may be important to note when planning adaptation interventions around the aged.

Data

Table 4.3.1: Risks of mortality associated with extreme temperatures.

Age/cause group	Deaths	Minimum Mortality Temperature Percentile (MMP)	Relative risk	
			1st percentile	99th percentile
All-cause, all-age	7,576,674	84 (56,89)	1.14 (1.10,1.17)	1.06 (1.03, 1.09)
Cardiovascular	1,154,896	80 (64,89)	1.33 (1.24,1.42)	1.08 (1.02, 1.14)
Respiratory	931,556	84 (60,90)	1.16 (1.07,1.25)	1.10 (1.03,1.18)
Other causes	5,490,222	84 (27,90)	1.09 (1.06,1.12)	1.05 (1.01,1.09)
<5 years	700,088	26 (1,44)	1.08 (0.99,1.18)	1.24 (1.15,1.34)
5–24 years	553,088	19 (9,99)	1.10 (1.00,1.20)	1.10 (1.00,1.20)
25–44 years	2,382,762	95 (1,99)	1.02 (0.97,1.06)	1.00 (0.97,1.04)
45–64 years	1,889,622	81 (47,99)	1.16 (1.09,1.22)	1.04 (0.99,1.08)
65+ years	2,016,041	85 (74,88)	1.34 (1.28,1.41)	1.13 (1.07,1.20)

Data notes

Graphs are drawn from the document as per data source below.

Data sources

Scovronick, N., Sera, F., Acquaotta, F., Garzena, D., Fratianni, S., Wright, C.Y. and Gasparrini, A., 2018. The association between ambient temperature and mortality in South Africa: A time-series analysis. *Environmental Research, 161*, pp.229-235.

Indicator status and recommendations for the way forward

Tier 3

Comment: This data was published in a research paper and is therefore not continuous, however it presents a case study that may be replicable. It is recommended that this be explored by Stats SA, Department of Health and SAWS.

INDICATOR 4.4: MALARIA

Indicator definition

Estimated number of malaria cases and deaths in South Africa.

Indicator rationale

Although there are many vector-borne diseases, the spread of which may be influenced by climate change, there are many other factors that could drive this. Malaria has the most direct correlation with climate and has therefore been selected as a proxy indicating an impact on health due to changing climate conditions. South Africa has a nationwide malaria elimination programme which may be jeopardised if the impact of climate variability and change is not considered. Pregnant women and children under five are the most vulnerable groups affected by malaria.

Data visualisation

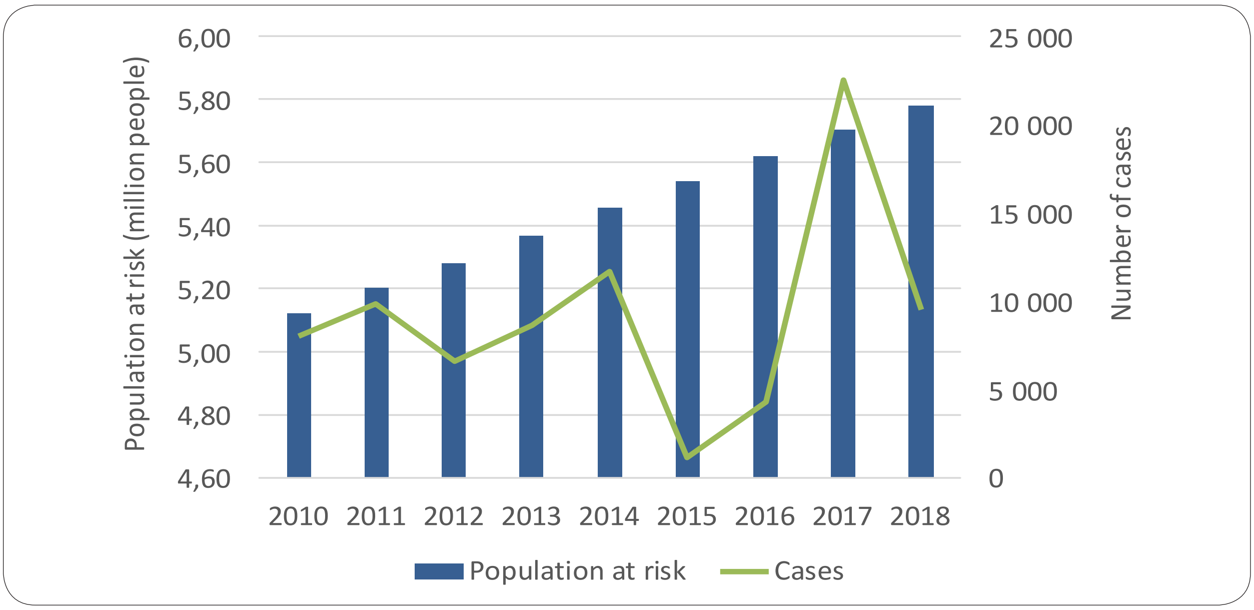

Figure 4.4.1: Population at risk (bars) and estimated number of malaria cases (line).

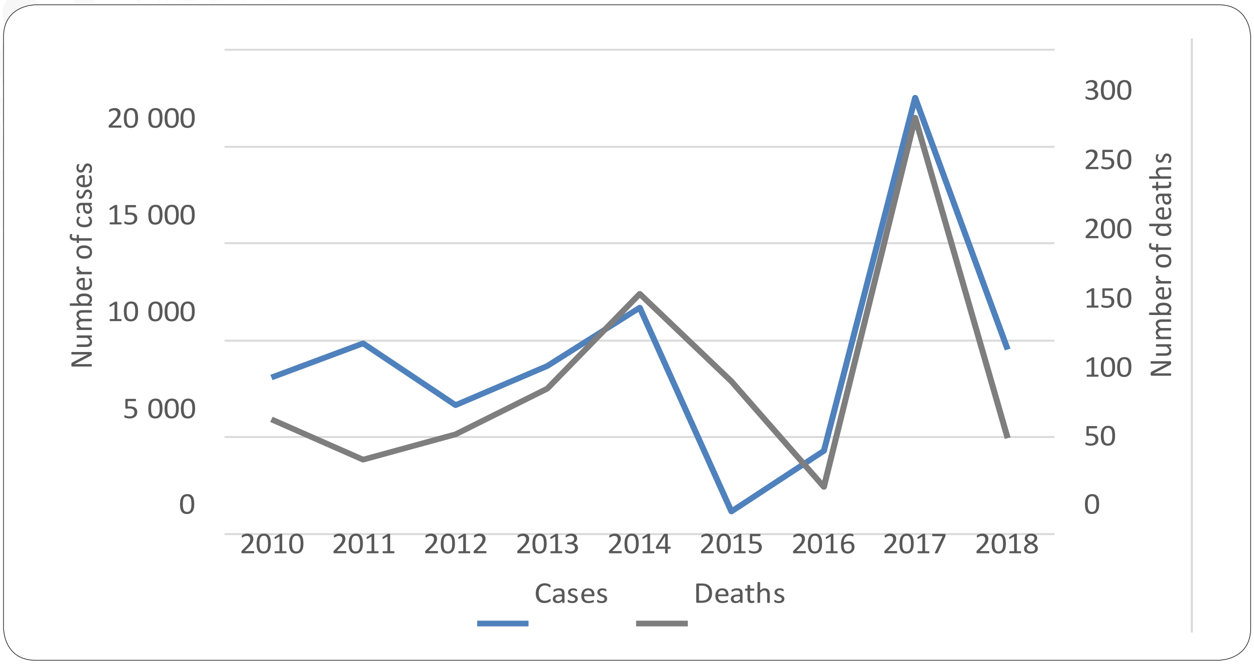

Figure 4.4.2: Estimated number of malaria cases (blue) and deaths (grey).

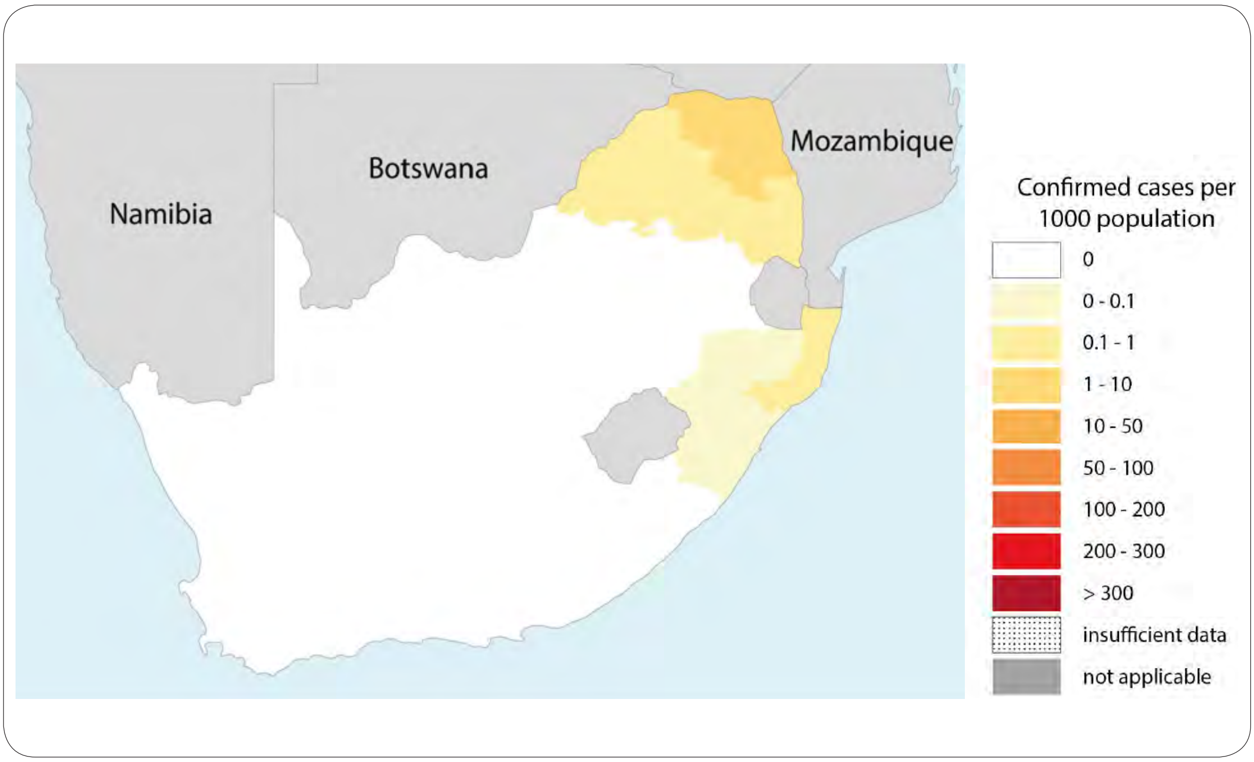

Figure 4.4.3: Spatial map of confirmed cases of malaria in South Africa, 2017.

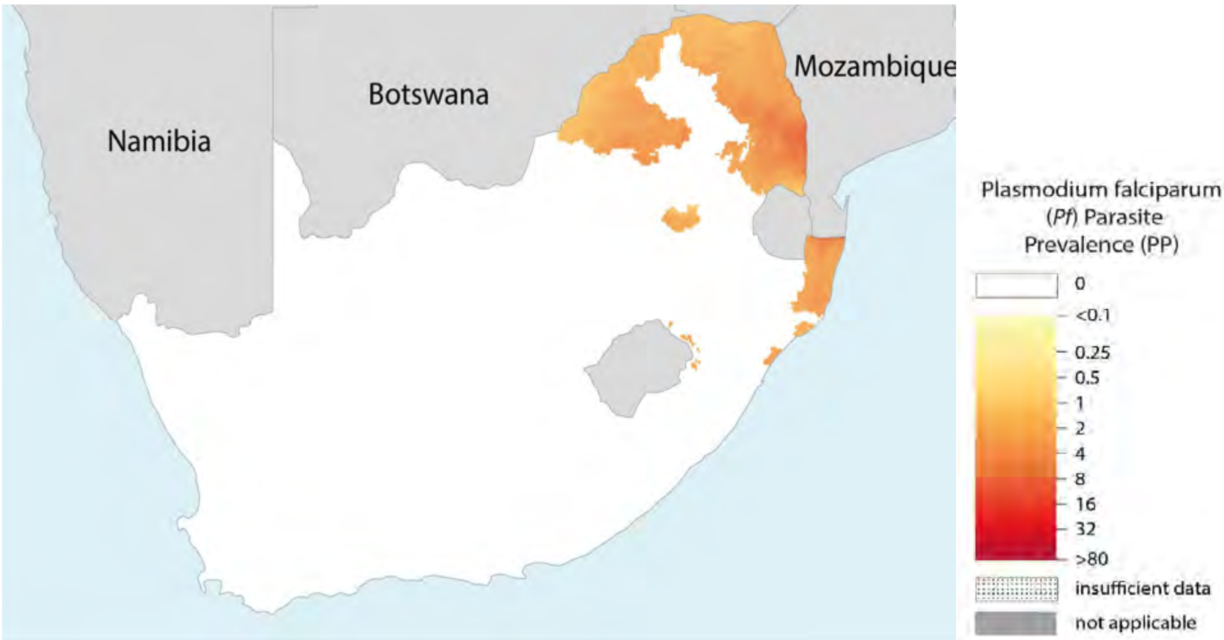

Figure 4.4.4: Spatial map of parasite prevalence in South Africa, 2017.

Analysis

Malaria is seasonal in South Africa peaking from January to May and is endemic in three provinces (Limpopo, Mpumalanga and KwaZulu-Natal). The population at risk has increased over time from just over 5.1 million in 2010 to almost 5.8 million in 2018. There have also been clear differences in malaria cases and deaths from year-to-year. Malaria cases remained relatively constant between 2010 and 2014. Low numbers of cases were reported in 2015 and 2016, before a big spike in 2017 when 22 517 cases and 301 deaths were reported. The number of cases and deaths returned to more normal levels in 2018.

Climate plays an important role in the variation seen in the data. The low numbers reported in 2015 and 2016 were associated with drought conditions and the upsurge seen in 2017 was associated with more favourable climate conditions. However, the state of vector control measures may also have influenced the number of cases.

Indoor Residual Spraying (IRS) is the primary intervention strategy employed in South Africa. According to the WMO 2018 country profile report, the percentage of at-risk population covered by IRS was high in 2010-2013 and 2014 (over 90%), but was only about 45% in 2013 and remained below 25% from 2015 to 2017.

The upsurge in cases which occurred in Limpopo during April 2017 illustrates the complexity of the issue. The high number of cases was impacted by the reduction in indoor residual spraying in areas where malaria cases had declined in previous years, but the timing of the increase in cases also coincided with the Easter long weekend when there was increased travel within South Africa and between adjacent malaria-endemic countries. The situation was made worse by the inadequate provision of rapid diagnostic test kits and oral antimalarials, and medical facilities became overburdened.

NARRATIVE 4 - SOCIAL VULNERABILITY

Data

Table 4.4.1: Population at risk and estimated malaria cases and deaths 2010-2018.

	Population at risk	Cases	Deaths
2010	5 121 696	8 060	83
2011	5 200 375	9 866	54
2012	5 283 265	6 621	72
2013	5 368 712	8 645	105
2014	5 454 418	11 705	174
2015	5 538 636	1 157	110
2016	5 620 764	4 323	34
2017	5 700 975	22 517	301
2018	5 779 252	9 540	69

Data notes

Needs to be tracked spatially.

Data sources

World Health Organization, (2019) *World Malaria Report*. World Health Organization, *Country Profile – South Africa, 2018*. Retrieved from https://www.who.int/publications-detail/world- malaria-report-2019

Indicator status and recommendations for the way forward

Tier 1

ANALYSIS AND REFLECTION ON INDICATORS IN THE SOCIAL VULNERABILITY NARRATIVE

Although poverty and inequality levels show a slight decline over the period represented (2006-2015), the overall figures remain extremely high as can be observed in Indicator 4.1.

As much as the very high levels of deprivation, inequality and unemployment need to drop urgently, the presence of social protection in the face of climate change bodes well and should be an ongoing priority in order to reduce fatalities and suffering. However, in a country with a high national debt burden and extremely low levels of economic growth, it is going to be difficult to sustain, particularly if unemployment levels continue to rise at such a rapid rate. It is therefore critical that employment and job creation are prioritised to reduce social vulnerability, in conjunction with policy aimed at reducing inequality, particularly addressing the concentration of deprivation across population groups, gender and geography.

One of the key indicators of this would be the gap between the demands of the labour market and the supply of appropriately skilled labour force. This has been partly addressed in Narrative 1, but an indicator tracking education outcomes across population groups, gender and geography could be considered in this narrative, given the importance of education as a key determining factor of employment, and unemployment being a significant driver of social vulnerability. Gender is a key distinguisher when it comes to disadvantaged groups, however, none of the indicators presented in this narrative are disaggregated by gender. This was partly due to the indicators selected and the need to keep the indicators simple in the first draft set of national climate change indicators. However, the indicator set that displays the gender disparity well is the employment figures by education level, real monthly earnings by gender. This could be included in future iterations of this indicator suite.

Considering the increase in recorded temperatures, as well as the exponential rate of increasing temperatures reported in Narrative 0, tracking the health risk posed by temperature extremes is important. A case study is presented in Indicator 4.3 that illustrates the interrogation of district level health data against temperature records, revealing a concentration of vulnerability in the young and the aged, as well as those with underlying cardiovascular and respiratory health conditions. Although a once off study, this could provide a methodology for ongoing monitoring, which would be extremely useful given the significance of the temperature statistics presented in Narrative 0. In another health-related indicator, the expansion of the malaria area has a direct climate signal, and as shown in Indicator 4.4 the population at risk has increased over the reporting period. The timing of preventive measures in relation to weather forecasts and climate projections needs to be monitored carefully, as a downswing in preventive measures in areas not currently very susceptible and considered 'under control' or low risk may coincide with a change in the conditions and an increase in risk that may not get picked up proactively.

Two further areas of concern which are not covered in this narrative, but should be considered in future iterations is a link to food security as well as internet access. This was highlighted by the recent Covid-19 outbreak and national response which included the declaration of a national state of disaster and a national lockdown. Both food supply chains and internet access are named as essential services under these conditions. Food security, in terms of access, availability and affordability, is closely linked to the 'triple challenge' of inequality, poverty and unemployment, which are the cornerstone indicators in this narrative. An indicator considered in this regard was 'incidence of stunting in children under five years', which provides insight into food security as well as general deprivation due to socio-economic disadvantage. It can also be traced with regard to educational outcomes and the role this plays in the persistence of poverty.

In the age of the fourth industrial revolution, 'internet security' in the form of access, availability and affordability is key to early warnings, disaster response and general information sharing and awareness regarding climate change. Similarly to food security, internet security is tied to socio- economic status, and therefore gives rise to a situation whereby disadvantaged groups are once again sidelined and excluded from mainstream online messaging and support. Consideration should be given in future iterations on how this key indicator can be represented under this narrative.

Another indicator worth consideration is the climate proofing of emergency facilities – particularly healthcare, fire and disaster response. For example, care facilities for the young and the aged should receive targeted interventions given the vulnerability to temperature extremes amongst these groups. This could be closely tied to climate proofing of critical infrastructure, such as key transport routes, water supply and sanitation services, electrical and communication infrastructure. There have been several incidents of hospitals flooding or running out of water.

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THEMATIC AREA

NARRATIVE 5

SUSTAINABLE URBAN CENTRES

Contents

Figures and Tables

INTRODUCTION TO THE SUSTAINABLE URBAN CENTRES NARRATIVE

South Africa's urban areas include its metropolitan municipalities (metros), as well as municipalities classified as secondary cities or large towns. The focus here is on the eight metros, which collectively hold over 40% of the country's population and generate over 50% of the national GDP (Arndt *et al.*, 2018). Urbanisation is a rapidly growing trend in the South African metros, as it is in cities across the African continent, and is coupled with the growth of the urban fringe, or peri-urban edge, and growing informality (Pieterse and Parnell, 2014).

As centres of economic activity, and with GDP per capita significantly higher than for other municipalities, metros offer the promise of economic opportunity and employment. However, South African metros tend to be highly unequal, with disparity in the delivery of basic services such as water, electricity and sanitation, as well as disparity in the quality of infrastructure and maintenance across different parts of the cities. Such unequal access to services, infrastructure and maintenance results in differential climate vulnerability across urban spaces. The location of settlements and quality of building structures, and the nature of access to water and sanitation, renders some areas and people more vulnerable than others to extreme events such as flooding, and to the more drawn out impacts of drought, for example. With dense populations that are frequently located in areas at risk from climate related hazards, the demand for appropriate disaster risk reduction is high.

South African urban areas are low-density by world standards, largely because of apartheid spatial planning. Coupled with dysfunctional public transport systems this results in high reliance on liquid fuel dependent private vehicle transport, and generally high transport emission profiles amongst the urban upper-middle class. It also results in great transport inequality as the urban poor, often based at the urban fridge, need to make do with a poorly functioning public transport system. There is scope for investment in low-carbon transport options, including functioning and integrated public transport systems that reduce the reliance on transportation modes that contribute significantly to greenhouse gas emissions, while also reducing transport inequality.

Buildings and infrastructure are central characteristics of urban centres. Here lies an opportunity for both adaptation and mitigation measures in addressing climate change. There is scope to improve building standards to include climate-smart and climate-proof designs, reducing among other things water and energy usage while planning for climate extremes such as droughts and heatwaves. Cities are prone to the urban heat island effect, which means they will have higher ambient temperatures than the surrounding rural areas. This is primarily due to dark artificial surfaces such as asphalt and buildings absorbing light and radiation that is emitted as heat, as well as heat released from cars and air conditioners. Any global temperature increases as a result of climate change will be amplified in cities, making them points for concentration of measures to adapt to the changing climate. While city greening can help cushion the urban heat island effect, maintaining healthy urban ecosystems can play an important role in buffering extreme weather events, such as coastal storm surges, and supporting the provision of clean drinking water. Most South African metros draw from rivers and dams as their sole source of water, yet with climate change and an expanding population relying on a single source of water may no longer be feasible.

Four of South Africa's eight metros, Buffalo City, Nelson Mandela Bay, the City of Cape Town and eThekwini are located on the coast. Coastal inundation, which happens when sea water rises high enough to flood infrastructure and buildings and endanger people, is thus a great climate change risk for urban South Africa. Precautionary disaster risk reduction, together with climate change mainstreaming into urban spatial planning and zoning, has the potential to play a role in reducing such risks.

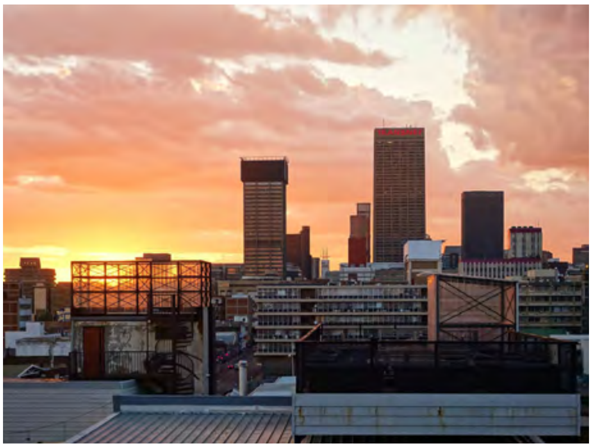
5.1 **INDICATOR 5.1:** URBAN POPULATION GROWTH

Indicator definition

The population growth of the metropolitan municipalities by showing the percentage change in population between censuses.

Indicator rationale

This indicator measures how rapidly the urban population is growing. This has implications for urban sprawl and density as well as levels of resources and employment in cities – all of which underlie vulnerability to a changing climate.



Data visualisation

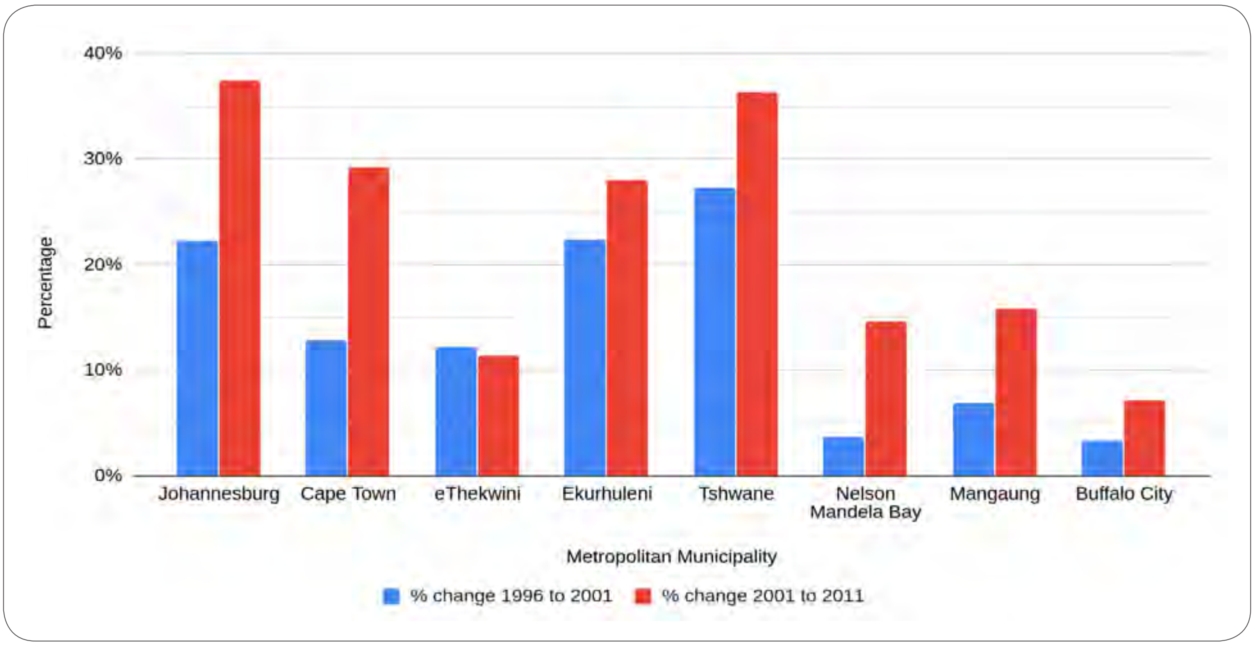


Figure 5.1.1: Percentage change of urban populations in the major South African metros.

Analysis

Between the 2001 and 2011 censuses, four of the major metros showed the greatest percentage growth in population. These included Tshwane (36%), Ekurhuleni (28%), Johannesburg (37%) and Cape Town (29%). Despite currently being the municipality with the third highest population, eThekwini was the anomaly, showing a relatively smaller drop in population from 12% to 11%. It can be expected that the major metros will attract the largest population growth as they are the economic hubs of South Africa. This trend is expected to continue going forward.

Data notes

The Census used to be every five years (i.e. 1996, 2001) but was extended to ten years due to capacity constraints (i.e. 2001, 2011).

Data sources

Statistics South Africa, (1996, 2001 and 2011) Census population size. Retrieved from http://www.statssa.gov.za/census/

Data

Table 5.1.1: Percentage change of urban populations in the major South African metros.

Metros	% change 1996 to 2001	% change 2001 to 2011
Johannesburg	22.2	37.5
Cape Town	12.8	29.3
eThekwini	12.3	11.4
Ekurhuleni	22.4	28.1
Tshwane	27.3	36.4
Nelson Mandela Bay	3.7	14.5
Mangaung	6.9	15.8
Buffalo City	3.3	7.1

Indicator status and recommendations for the way forward

Tier 2

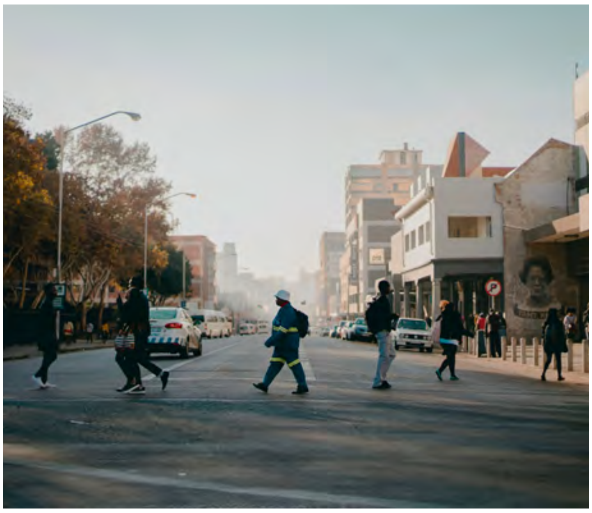
Comment: The now 10-year cycle of the South African Census is not conducive to monitoring. Going forward alternative datasets should be explored in collaboration with Statistics South Africa, for application in future reporting.

This indicator requires discussion with Statistics South Africa, with regards to verification of the data and graphs presented, as well as the choice and sharing of data.

5.2 **INDICATOR 5.2:** URBAN DENSITY

Indicator definition

The number of people per square kilometre at each metropolitan municipality.



Indicator rationale

Urban density correlates closely with emissions and walkable, liveable cities. While dense living may not be socially desirable, a densified city allows for shorter commute times and greater scope for lower-emission transport options. However, a dense city should not always be interpreted positively. Density represents the potential to create a sustainable city rather than it being an indicator of a sustainable city in itself.

Data visualisation

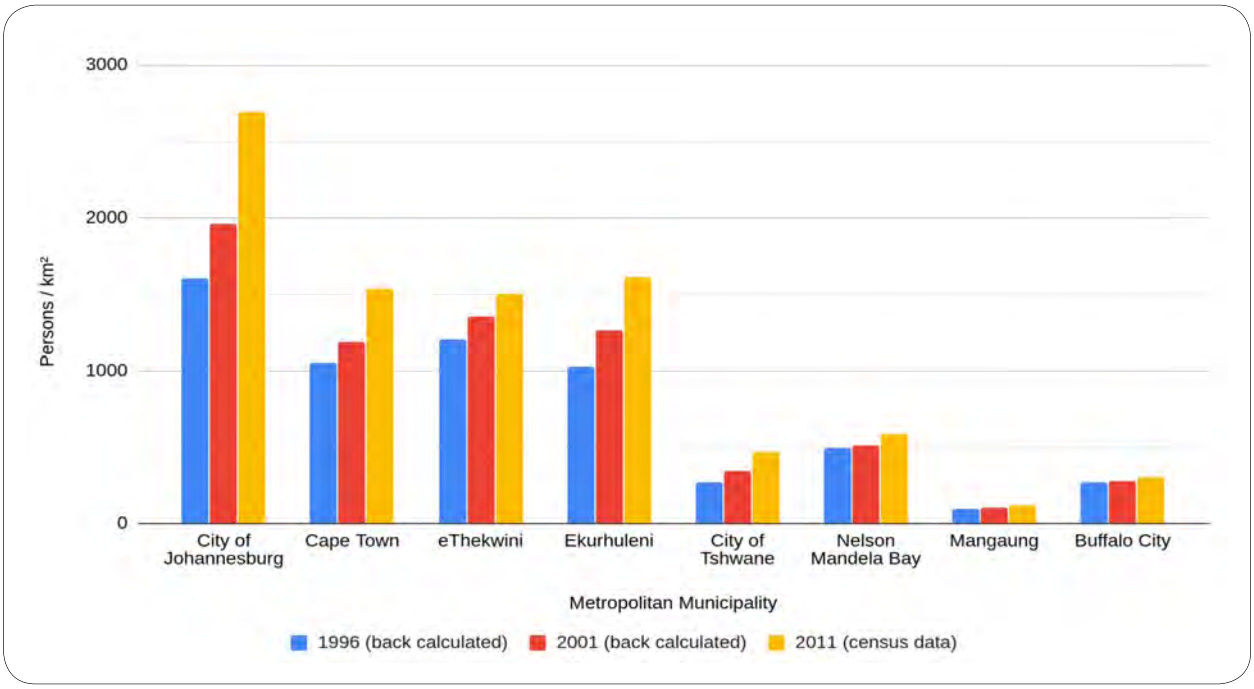


Figure 5.2.1: Urban density of major South African metros assuming urban areas remain the same between censuses.

Analysis

As expected, four of the five major metros show the greatest urban density. This increased between 2001 and 2011, particularly in the City of Johannesburg. The City of Tshwane is the anomaly showing a relatively low urban density in comparison to the other major metros. Overall the data period shows a steady increase in population density in all metros.

Data notes

An urban density figure was only available from the 2011 Census, however, previous years have been calculated using population figures with the assumption that the urban area has remained the same.

The census used to be every five years (i.e. 1996, 2001) but was then extended to ten years due to capacity constraints (i.e. 2001, 2011).

Data

Table 5.2.1: Urban density of major South African metros assuming urban areas remain the same between censuses.

Metros	1996 (back calculated)	2001 (back calculated)	2011 (census data)
Johannesburg	1 604	1 961	2 696
Cape Town	1 049	1 183	1 530
eThekwini	1 200	1 348	1 502
Ekurhuleni	1 026	1 256	1 609
Tshwane	267	340	464
Nelson Mandela Bay	495	513	588
Mangaung	96	103	119
Buffalo City	269	278	298

Data sources

Statistics South Africa, (1996, 2001 and 2011) Census report. Retrieved from http://www.statssa.gov.za/census/

Indicator status and recommendations for the way forward

Tier 2

Comment: In the South African context the notion of a dense, walkable city is complicated by dense informal settlements and back yarding where the standard of living is low and vulnerability to climate extremes is high. Further thought is needed about how this duality of urban density can be considered in this indicator. It may be that urban density needs to be looked at in relation to changes in informal versus formal housing and back yarding, to see whether the density indeed reflects a city with a good living standard. One possibility could be to compare the density of the city overall with a high-income ward and low-income ward at a distance from the economic hub.

This indicator also requires discussion with Statistics South Africa with regards to verification of the data and graphs presented, as well as the choice and sharing of data going forward.

5.3 INDICATOR 5.3: MULTI-YEAR DROUGHT AND URBAN WATER SUPPLY

Indicator definition

A measure of multi-year meteorological drought over the DWS Water Management Areas (WMA), where urban water supply systems operate, by looking at the Standardised Precipitation Evaporation Index (SPEI).

Indicator rationale

Most large metropolitan water supply systems in South Africa rely on large surface storage reservoirs capturing rainfall across regional catchments. The DWS has delineated 12 WMAs within which water resources are managed and allocated to different uses including agriculture and urban water supply. The WMAs are therefore a reasonable spatial aggregation for urban water supply and drought impacts.

The SPEI is a widely used meteorological drought index because it integrates both rainfall and evaporation/temperature variability. This means that the effect of high temperatures on water deficit is integrated into the index. SPEI can be calculated over different time periods and for urban water supply systems a four-year integration of SPEI has been selected. Urban water supply systems are typically designed not to fail under single-year drought conditions as reservoirs provide some buffering of the water supply. However, beyond three years many systems will begin to, and have been seen to, become stressed requiring strong demand management and restrictions (e.g. Cape Town). The four-year (48-month) SPEI index therefore provides a good indication of these important multi-year drought conditions.

Data visualisation

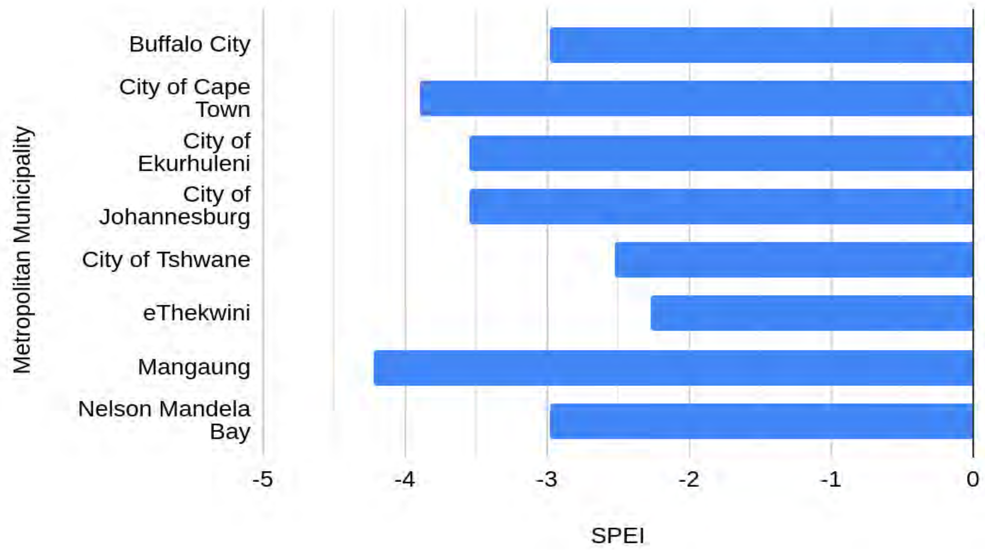


Figure 5.3.1: Average Standardised Precipitation-Evaporation Index (SPEI) (last 48 months / 4 years) values for the Water Management Areas relevant to the major South African metros.

Analysis

All metros are located within WMAs that have a strongly negative SPEI for the four years from 2015-2019, indicating that South Africa's major metros are likely experiencing or have experienced drought-related challenges to water resource management in the past four years.

With a SPEI value of -1 indicative of moderate drought, and the metro SPEI's ranging from - 2.27 in eThekwini to -4.22 in Mangaung, indicating drought conditions across South African metros that are moderate to severe.

Data

Table 5.3.1: Average Standardised Precipitation-Evaporation Index (SPEI) (last 48 months / 4 years) values for the Water Management Areas relevant to the major South African metros.

Metros	Standardised Precipitation-Evaporation Index (SPEI)
Buffalo City	-2.98
City of Cape Town	-3.89
City of Ekurhuleni	-3.55
City of Johannesburg	-3.55
City of Tshwane	-2.52
eThekwini	-2.27
Mangaung	-4.22
Nelson Mandela Bay	-2.98

Data notes

For each metro the analysis relates to the WMA within which it is physically based, which means that the City of Johannesburg and the City of Ekurhuleni show the same value because they are in the same WMA.

Urban water resource management is complex and different urban centres have very different water supply systems and management approaches. This analysis does not account for water transfers between the WMAs and other water resource management activities. This indicator is broad based and generic and should be used to highlight potential impact but not replace specific analysis of urban water supply stress.

The SPEI data is based on global datasets and has been spatially aggregated to local Water Management Areas.

Data sources

Beguería, S., Latorre, B., Reig, F and Vicente-Serrano, S. M. SPEI drought monitor. CSIC (Spanish National Research Council). Retrieved from https://spei.csic.es/map/maps.html

Indicator status and recommendations for the way forward

Tier 2

INDICATOR 5.4: URBAN FLOODING

5.4

Indicator definition

The number of urban flood events and associated human and economic impacts.

Indicator rationale

Urban flooding is a key risk associated with climate change, but flooding impacts result from both heavy rainfall events as well as poor infrastructure. Indicators of extreme rainfall seldom sufficiently capture the complexity of urban flooding. Analysis of high-impact flood events and the social and economic impacts that follow provide more realistic indications of the impact of urban flooding.

Data visualisation

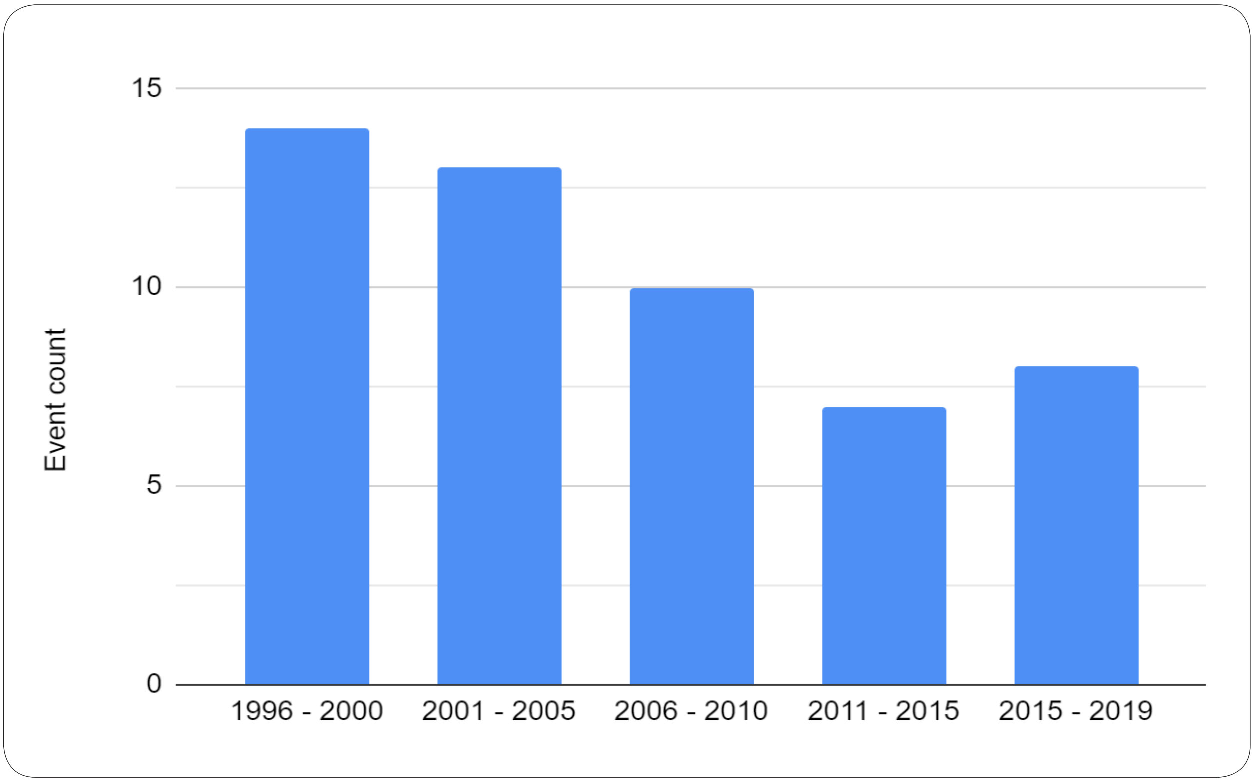


Figure 5.4.1: South African urban flooding disaster events (as recorded by EM-DAT).

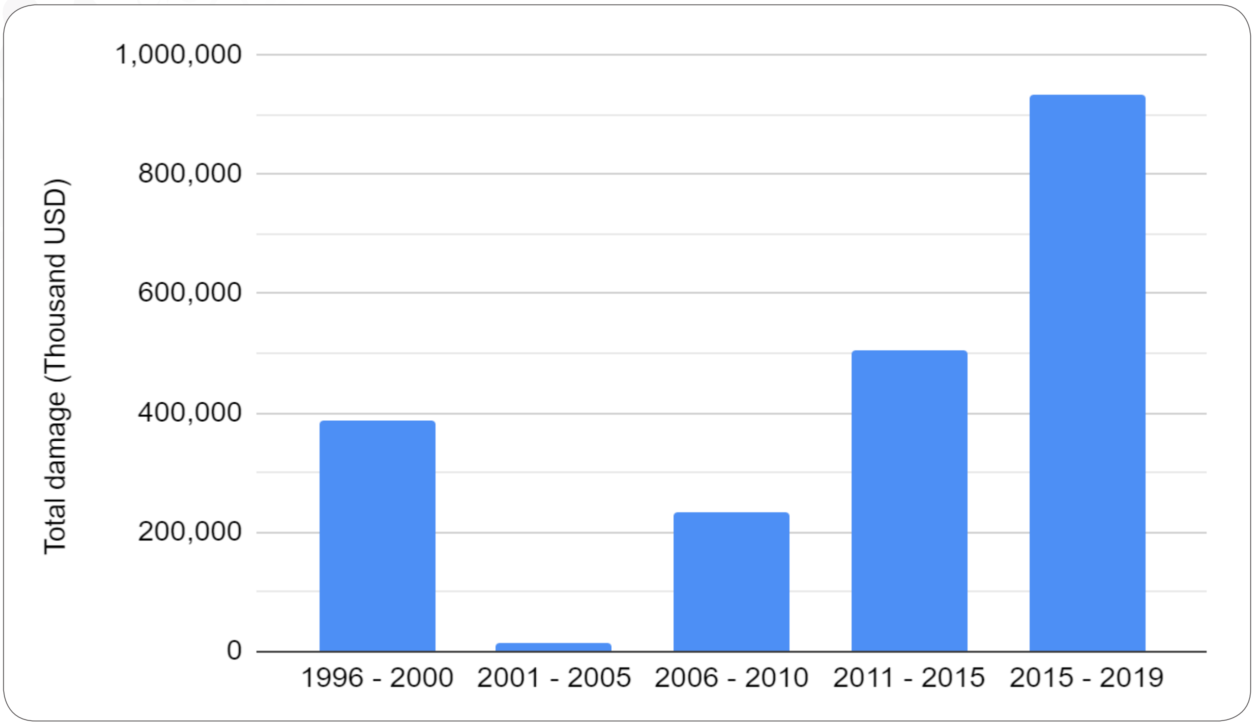


Figure 5.4.2: Total damage (monetary value) caused by South African urban flooding disaster events (as recorded by EM-DAT).

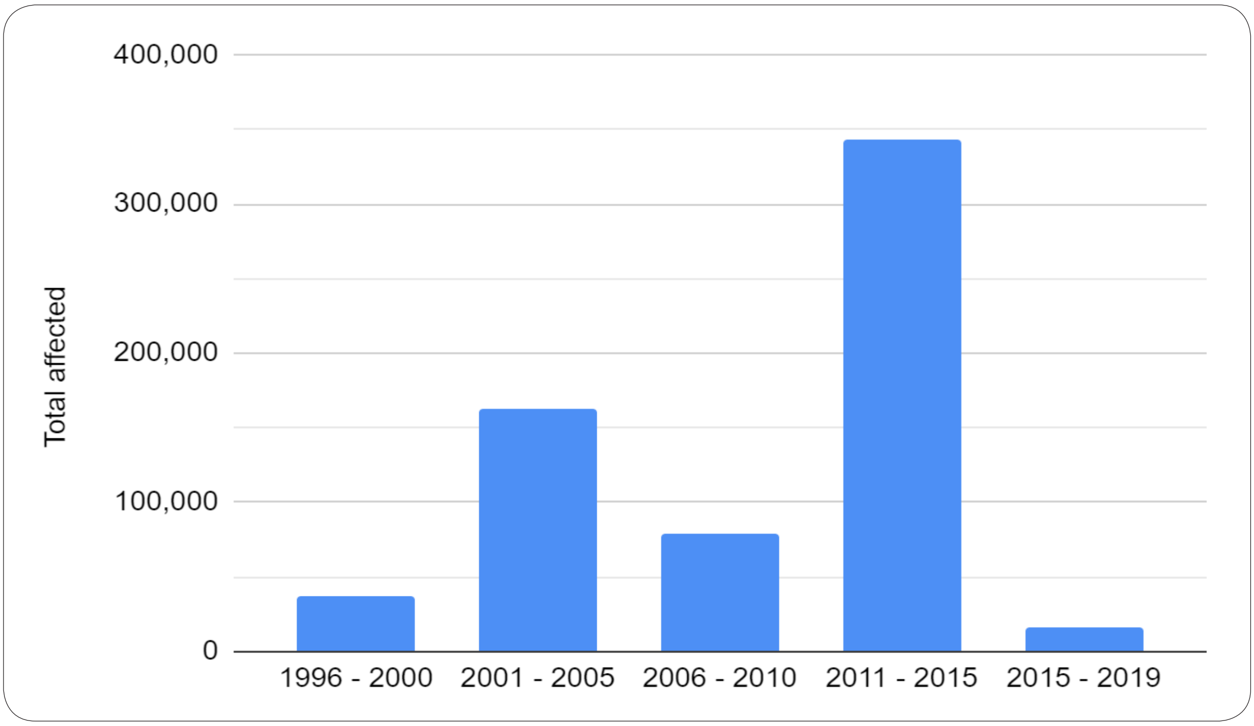


Figure 5.4.3: Total number of people affected by South African urban flooding disaster events (as recorded by EM-DAT).

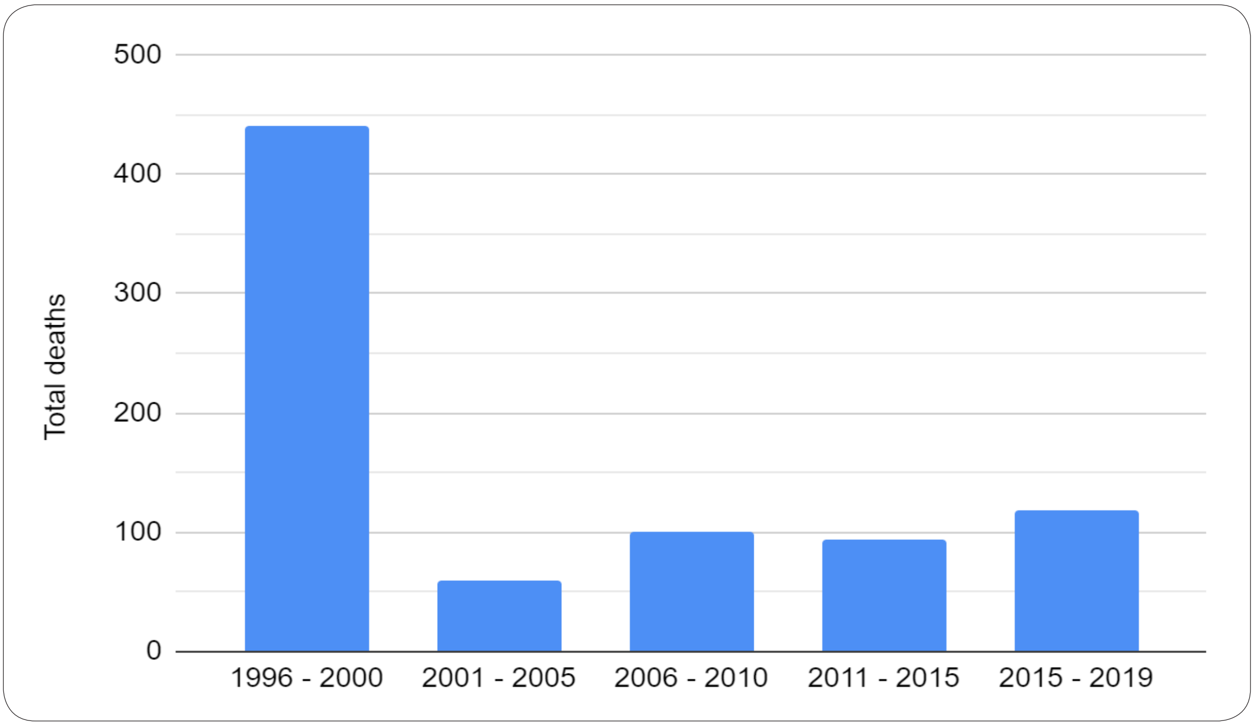


Figure 5.4.4: Total number of deaths caused by South African urban flooding disaster events (as recorded by EM-DAT).

Analysis

The number of flood events reported has been declining while total damage has been increasing. The reasons for this are likely multifaceted, it could for example relate to changes in urban infrastructure (increase in high value property) or urban densification, or it could relate to an increase in the intensity, yet a decrease in the frequency, of extreme rainfall events. For instance, 2011-2015 had the least number of flood events but the total affected and total damage was relatively high compared to previous years with higher numbers of flood events. Understanding the drivers of this change requires further investigation into the interaction between the hazard (intense rainfall) and exposure and vulnerability in urban areas.

Data notes

Note that the data only includes events that were geographically identified as taking place in one of the eight metros specifically and does not include events that were geographically logged at a greater scale (e.g. provincial scale) but which may have also influenced the metros.

A caveat is that the EM-DAT disaster event database likely does not represent South Africa well and does not include many smaller events. The SAWS Caelum database or records from the National Disaster Management Centre (NDMC) would likely provide a much more appropriate dataset.

Data

Table 5.4.1: South African urban flooding disaster events, total deaths, total people affected and total damage (as recorded by EM-DAT).

	Event count	Total damage ('000s USD)	Total affected	Total deaths
1996 - 2000	14	386 460	37077	440
2001 - 2005	13	14 041	163124	59
2006 - 2010	10	232 264	79036	101
2011 - 2015	7	506 000	343049	94
2015 - 2019	8	933 000	16136	119

Data sources

Emergency Events Database (EM-DAT) Website. The International Disasters Database. Retrieved from https://www.emdat.be/database

Indicator status and recommendations for the way forward

Tier 2

Comment: Alternative, local sources of primary data will need to be applied in future reporting through collaboration with the NDMC.

ANALYSIS AND REFLECTION ON INDICATORS IN THE SUSTAINABLE URBAN CENTRES NARRATIVE

Consistent with trends on the continent and beyond, Indicator 5.1 and 5.2 illustrate how all the eight South African metros show considerable population growth and increasing urban density. Growing population rates alongside increasing density and decreasing informality can be seen as positive, if that increasing urban density means that cities are becoming more compact and efficient spaces – where high density enables efficient service delivery and transport – and if it means that people have decent housing that is located in areas with low hazard risk and proximity to economic activity. Investigation of the wards in which densities are increasing, and assessments into their proximity to the key areas of economic activity and related transport connectivity, as well as levels of service delivery, are required to get a better picture of whether the cities are becoming more sustainable and equal. Further deliberation by urban experts, including both academics and city practitioners, on these three indicators is required to ensure that future iterations of the report and indicators give a clearer picture of what these changes mean for South African urban areas.

Several urban narrative indicators consider the prevalence or the impact of climate-related hazards, including drought, floods, urban heat spells and coastal inundation. Lack of access and availability of data means that the latter two indicators cannot be completed at this point. The urban drought indicator 5.3 showed that all eight metros experiencing moderate to severe drought conditions during the course of four years. Seen together with the drought conditions reported on in the Water for Development Narrative Indicator 3.1, as well as the temperature Indicator 0.1 and rainfall Indicator 0.2, there is clearly a great need to monitor these trends closely.

There is a declining number of floods reported, as illustrated in Indicator 5.4 which aligns with the trends in extreme rainfall (Indicator 0.3) where many provinces are found to have experienced anomalously low numbers of intense rainfall events over the past decade. However, the damage reported in relation to the flooding events in the metros has been increasing. This could be linked to increased exposure (more buildings, communities, more assets of value etc. in places at risk of flooding), or the sensitivity or adaptive capacity of that or those exposed decreasing. Understanding these dynamics requires further investigation.

Buildings are themselves a source of emissions and resource use. The Green Star certification provided through the Green Building Council South Africa (GBCSA) is one way to track the move towards reduced emissions and efficient resource use across private and publicly-owned buildings. The relevant data, ideally the accumulative average annual Green Star certified space (in square metres) per metro, will hopefully be included in future iterations of the report.

With regards to the spatial scope of the narrative, this was simplified through the sole focus on the eight metros, for which data is relatively easily available. For future iterations it may be worth exploring the inclusion of secondary cities. Such cities are also important areas of urban growth – with the many challenges and opportunities that urban spaces bring.

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THEMATIC AREA

NARRATIVE 6

SUSTAINABLE RURAL AND SEMI-RURAL LANDSCAPES

Contents

Figures and Tables

INTRODUCTION TO THE SUSTAINABLE RURAL AND SEMI-RURAL LANDSCAPES NARRATIVE

Rural areas in South Africa hold around a quarter of the population and have the lowest GDP per capita (Arndt *et al.*, 2018). Despite a minimal urban population share, these areas tend to have high average population densities, particularly in the former homeland areas.

Commercial farming activities, which tend to dominate areas on the rural periphery, are also prone to the direct impacts of extreme events, climate variability and change, impacting yields and potentially shifting the extent of agriculturally-active areas. This has further implications for both food prices and jobs (e.g. farm workers). Greater sensitivity is seen amongst those relying on rainfed production, yet during times of intense or multi-year drought, irrigated areas are also impacted.

Rural development has long centred around agricultural activities, as well as mining, fisheries, and increasingly tourism. Rural economic development and resource extraction brings promises of benefits to some rural poor and marginalised communities. The social justice context of rural communities is one in which there is contestation, including around land rights, traditional governance, rights to resources, and the impact of mining on communities. Current threats to the sustainability of the natural asset base include urban and peri-urban sprawl, mining activities, coastal development, pollution and unchecked natural resource extraction. The nature of rural activities and how they are managed has implications for climate change, for example, in greenhouse gas emissions from land use change, agriculture, and from mining and related industries.

Climate change impacts and greenhouse gas emissions may be mitigated by adopting nature- based land management approaches and by adopting or integrating indigenous and local knowledge about natural resources and sustainability. Land management approaches play a valuable role in the sustainability of rural development activities. Conservation agriculture, which is based on three principles of minimal soil disturbances, continuous soil cover, and crop rotation, is seen to increase productivity and contributes to climate change mitigation by increasing the sequestration of carbon. The rehabilitation of degraded lands that have lost biological or ecological productivity, and the protection of land in arid, semi-arid and dry sub- humid areas that are vulnerable to climatic variation and human activities are vital for sustainability of ecological infrastructure in the long term. The biodiversity economy promises employment and business opportunities and a growing contribution to GDP. It will require the monitoring and assessment of resource extraction in order to ensure persistence of biodiversity and ecological function in the medium to long term.

Rural areas are home to important ecological infrastructure and the natural resource base. The protection and the management of their use and extraction is important for providing just and sustainable access to these natural resources, for current and future generations.

Rural livelihoods and much of the rural economy rely on ecological infrastructure, that is, the naturally functioning ecosystems that produce and deliver valuable services including fresh water, soil formation, pollination, flood attenuation and climate regulation. Functioning ecosystems rely on biodiversity, and they provide food, grazing, materials for building and for livelihoods and businesses. Damage to ecological infrastructure poses a threat to rural livelihoods and to people's adaptive capacity in the face of climate change.

NARRATIVE 6 - SUSTAINABLE RURAL AND SEMI-RURAL LANDSCAPES

Ecological infrastructure in rural areas is highly sensitive to environmental change and faces accelerated degradation as a result of climate change events like storm surges and shifts in seasonal and geographical patterns of precipitation. Highly sensitive areas include water catchments that are already degraded and contaminated by pollution, and coasts under pressure from unsustainable harvesting of species, inappropriate infrastructure development and pollution. Estuaries and beaches face seaward pressures from sea level rise and landward pressure from coastal development and coastal mining.

Rural landscapes reveal information to better understand climate change trends and impacts. The extent and nature of vegetation across the country may shift. Changes to seasons will impact agriculture if there are changes to periods of ripening or dormancy for plants. Fire regimes will likely shift, with drier and hotter conditions creating greater flammability, yet also potentially reducing the biomass that fuel fires. This has implications for both changes to the frequency and severity of fire hazard risk, as well as the extent of burnt areas.

INDICATOR 6.1: HOUSEHOLD FOOD INDEX

6.1

Indicator definition

The total food costs of a food basket consisting of 38 basic foods, as well as individual costs of 15 basic foods.

Indicator rationale

South African households are net buyers of food, and access to food thus largely requires money. Changing food prices tend to hit low-income households with minimal disposable income the most. Focusing on the changing costs in basic foods generally consumed by low-income households provides an indication of the strain that these households face as prices fluctuate. Fluctuations in food costs can be attributed to a variety of interrelated factors including but not exclusively, weather and climate change.

Data visualisation

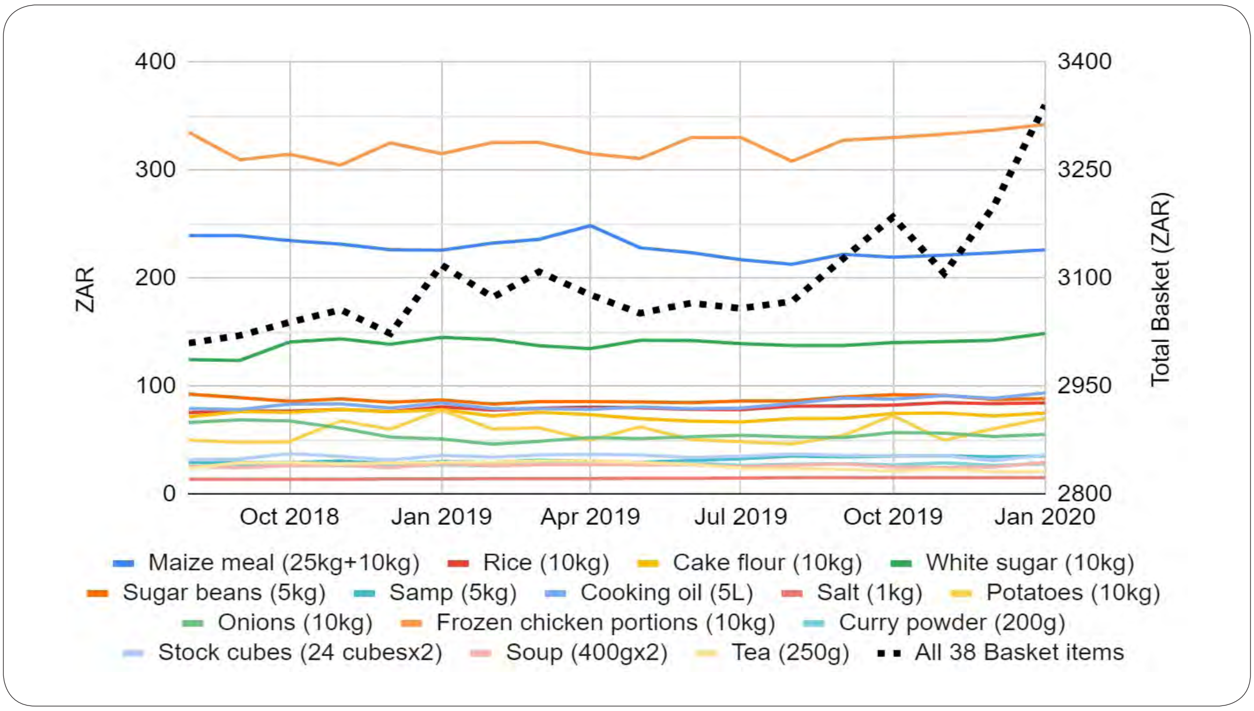

Figure 6.1.1: Total food basket price (dotted line) and prices for core food items (solid lines), for August 2018 to January 2020 (Pietermaritzburg, South Africa).

Analysis

While individual food item prices have been both increasing and decreasing, collectively there has been an overall increase with the total food basket cost increasing from about R3010 in June 2018 to about R3340 in January 2020. Of the 15 core foods, the individual food item that has seen the greatest increase in nominal terms is white sugar, followed by potatoes and cooking oil. Moreover, the increase in potato prices has seen the greatest increase relative to its initial price, as it went from R50,23 in August 2018 to R69,96 in Jan 2020.

Food price increases and fluctuations place strain on low-income households with low financial adaptive capacity. Further investigation is required to understand the drivers of price increases and fluctuations of core food items, and the times at which, if at all, climate and weather plays a role.

Data

Table 6.1.1: Total food basket price and individual prices for core food items (in rands) from August 2018 to January 2020 (Pietermaritzburg, South Africa).

	Maize meal (25kg + 10kg)	Rice (10kg)	Cake flour (10kg)	White sugar (10kg)	Sugar beans (5kg)	Samp (5kg)	Cooking oil (5L)	Salt (1kg)	Potatoes (10kg)	Onions (10kg)	Frozen chicken portions (10kg)	Curry powder (200g)	Stock cubes (24 cubes x 2)	Soup (400g x 2)	Tea (250g)	All 38 Basket items
Aug 2018	239.16	75.49	71.66	124.49	92.66	29.66	79.16	13.74	50.23	66.54	334.98	26.16	31.65	25.98	23.99	3 009.65
Sep 2018	239.32	76.99	76.49	123.82	89.32	29.49	78.32	13.91	48.09	68.8	309.48	26.49	32.65	24.65	29.16	3 020.28
Oct 2018	234.58	76.82	75.66	140.82	85.82	29.16	83.49	13.91	48.68	67.8	314.48	27.99	37.65	26.31	29.16	3 038.50
Nov 2018	231.38	78.32	78.33	143.66	88.16	30.82	83.66	13.91	67.97	61.18	304.48	26.49	34.98	26.98	27.99	3 056.05
Dec 2018	226.18	76.49	76.32	138.83	85.16	28.49	79.66	14.19	60.23	52.92	324.98	25.82	31.65	24.65	28.82	3 022.90
Jan 2019	225.78	80.82	78.16	145.16	87.33	30.16	84.49	14.19	77.97	51.18	314.98	27.16	35.98	28.31	29.32	3 118.28
Feb 2019	232.38	77.82	72.49	143.16	83.32	29.66	79.16	14.36	60.25	46.33	325.39	26.32	34.31	26.31	29.82	3 073.22
Mar 2019	235.78	79.49	75.82	137.32	85.79	31.49	79.16	14.36	61.42	48.95	325.49	27.99	36.31	27.31	30.66	3 108.77
Apr 2019	248.48	80.49	73.66	134.66	85.66	30.32	78.66	14.44	49.97	52.47	314.99	28.66	36.98	27.48	30.82	3 076.76
May 2019	227.97	79.99	69.99	142.39	85.39	29.39	80.79	14.79	62.42	51.47	310.49	27.59	36.38	27.18	29.39	3 051.11
Jun 2019	223.52	78.59	67.59	142.19	84.79	31.39	79.19	14.79	50.56	53.27	329.99	28.79	33.98	27.18	27.59	3 065.28
Jul 2019	216.9	78.19	66.79	139.39	86.19	32.79	79.79	14.99	48.71	54.5	329.99	26.79	35.18	25.58	23.99	3 057.93
Aug 2019	212.66	81.39	69.99	137.59	86.19	35.39	83.99	15.39	46.59	52.99	307.99	27.59	37.18	26.78	23.39	3 067.52
Sep 2019	221.97	81.59	70.19	137.59	89.99	34.59	88.99	15.39	54.42	52.55	327.48	28.19	35.98	27.98	22.99	3 127.21
Oct 2019	219.22	82.39	74.79	140.19	91.99	35.39	87.99	15.39	72.7	57.13	329.98	27.19	35.58	25.18	21.39	3 184.63
Nov 2019	221.22	84.79	75.19	141.19	91.39	35.59	91.19	15.39	49.79	56.56	332.94	28.99	35.58	24.78	22.99	3 106.42
Dec 2019	223.23	83.79	72.39	142.39	87.59	34.59	88.79	15.39	60.74	53.41	336.94	26.79	31.18	25.18	20.79	3 199.86
Jan 2020	226.23	226.23	75.19	148.79	88.39	35.39	93.79	15.39	69.98	55.3	341.98	28.19	36.38	29.58	21.19	3 339.98

Data notes

The data is collected on a monthly basis by the Pietermaritzburg Economic Justice & Dignity (PMBEJD) Group.

The food options have been identified in collaboration with women living on low incomes, and volumes are estimated for a seven-person household.

Data sources

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Indicator status and recommendations for the way forward

Tier 3

Currently showing: Pietermaritzburg case study

Required: Thinking as to how to scale up method and data, or on other ways to capture transition to conservation agriculture practices.

Comment: This indicator could remain a case study indicator, based on the Pietermaritzburg data that is regularly collected and analysed by Pietermaritzburg Economic Justice & Dignity. Making it more widely representative would require efforts to scale it up to include a number of locations across the country or tweaking in order to present, for example provincial food costs.

For this indicator to provide a valuable message it may however be worth mapping this against the minimum wage, showing the high proportion of household income being spent on food – and thus the low financial capacity that exists for dealing with food price fluctuations when they do come.

Showing the story of household food security as connected to climate change, and how it changes over time, is a challenging task. The team recognises that this is a weak indicator, and that food systems experts should be engaged to develop this indicator further – exploring whether this or potentially other datasets can provide a better picture.

6.2 **INDICATOR 6.2:** AGRICULTURAL LAND USE CHANGE

Indicator definition

The spatial extent of change in crop agricultural land use area per province.

Indicator rationale

Climate variability and climate change may impact the land area suitable, and thus being actively used, for crop agriculture. It may also influence the type of agricultural practices (e.g. non-irrigated to irrigated) or crop selection (e.g. orchards to vineyards).

Data visualisation

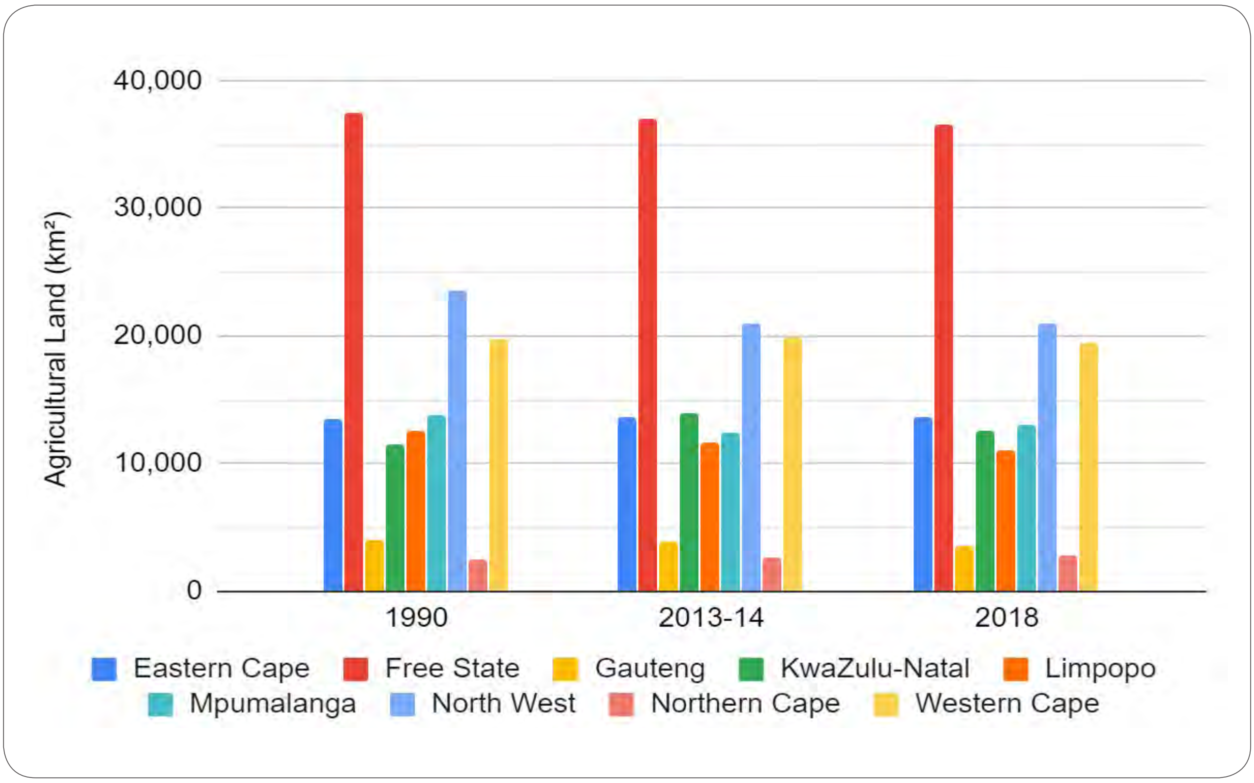


Figure 6.2.1: Agricultural land area per province.

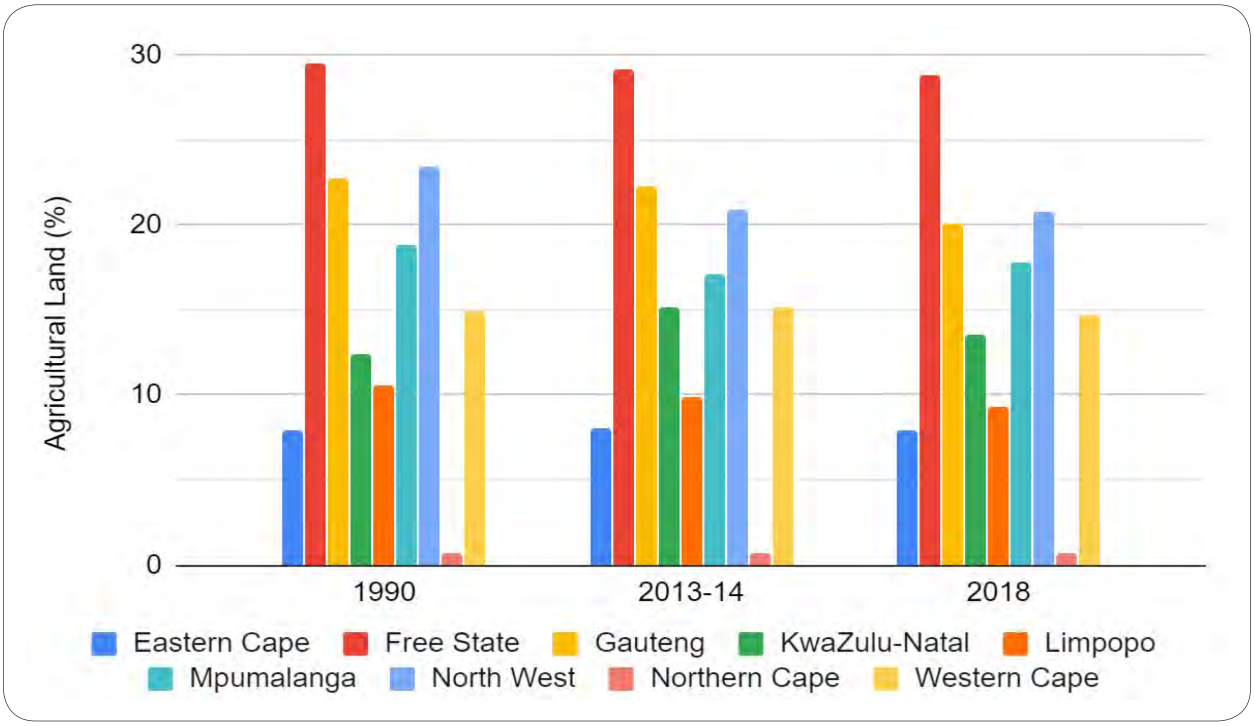


Figure 6.2.2: Proportion of provincial land that is used for agriculture.

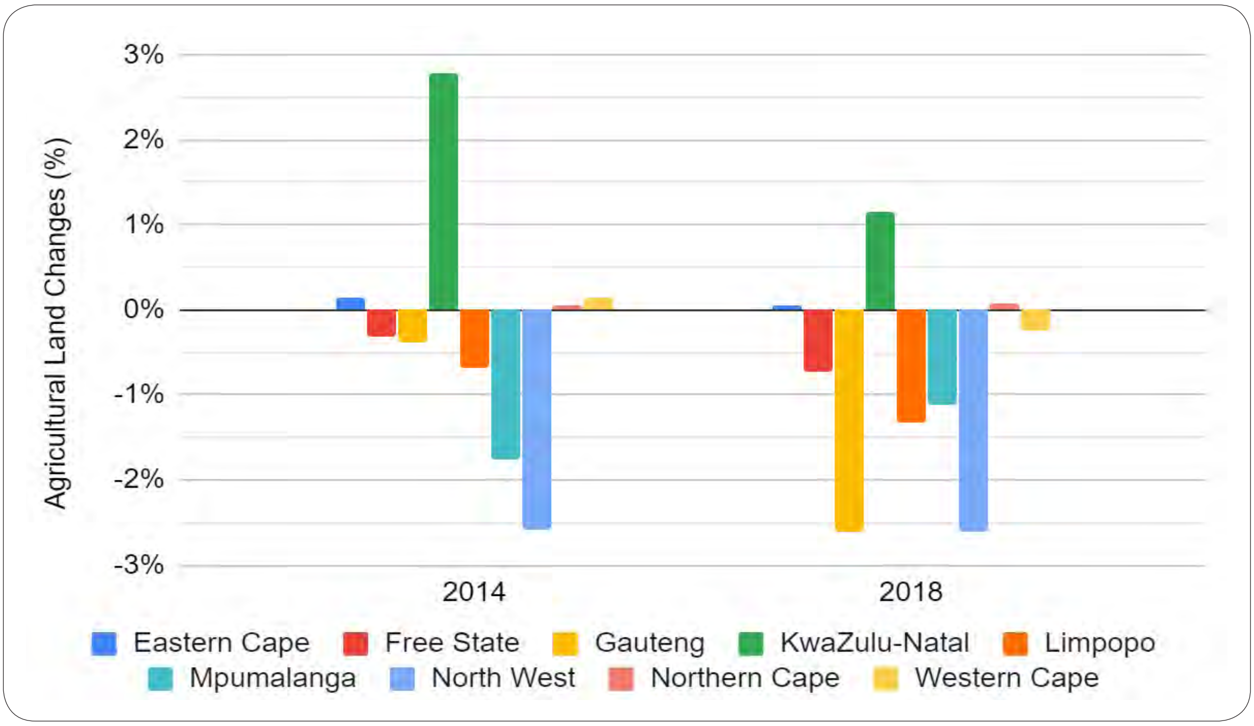


Figure 6.2.3: Percentage change of agricultural land area relative to 1990 per province.

Analysis

In 2018 the Free State province had the largest agricultural area (36,500 km^2) which represented 29% of the total provincial area. The North West and Western Cape provinces had roughly 20,000 km^2 of agricultural land each, which represented just over 20% and 15% of the total area respectively. Gauteng had a relatively small agricultural area, but it still represented 20% of the total area of the province. The area being utilised for agriculture has changed over time, however the changes are small. Most provinces experienced a decrease since 1990, with the exception of KwaZulu-Natal which experienced an increase in 2014 and to a lesser extent in 2018.

Further investigation is required to understand the drivers of land use changes, as agriculture plays an important role in food security and curbing unemployment.

Data

Table 6.2.1: Agricultural land area per province (km^2).

	1990	2013-14	2018
Eastern Cape	13 468	13 696	13 554
Free State	37 418	37 031	36 548
Gauteng	3 944	3 876	3 491
KwaZulu-Natal	11 434	13 997	12 502
Limpopo	12 497	11 712	10 962
Mpumalanga	13 749	12 471	12 949
North West	23 497	20 902	20 911
Northern Cape	2 447	2 666	2 711
Western Cape	19 772	19 968	19 469

Table 6.2.2: Agricultural land area as a proportion of total provincial area (%).

	1990	2013-14	2018
Eastern Cape	7.87	8.01	7.92
Free State	29.51	29.2	28.79
Gauteng	22.71	22.32	20.1
KwaZulu-Natal	12.39	15.17	13.54
Limpopo	10.6	9.93	9.28
Mpumalanga	18.85	17.09	17.74
North West	23.42	20.83	20.82
Northern Cape	0.67	0.73	0.74
Western Cape	14.95	15.1	14.7

Data notes

The South African National Land Cover (SANLC) raster layer is expected to be produced once a year starting from 2020. This will allow this indicator to be tracked more closely than in the past and provide a far more robust indication of any variation or trends in the spatial extent. It will also allow a more detailed analysis of different agricultural land area classes.

The indicator uses satellite-derived land surface classes. The satellite imagery used for the SANLC 2018 was the Sentinel 2 (20m resolution), while the older datasets used Landsat imagery. There are differences/improvements between the previous SANLC 1990 and SANLC 2013-14 datasets and the SANLC 2018. A table-based comparison between the legends used in the SANLC 2018 and the older datasets was used to select the appropriate land surface classes representing crop agriculture (class 32 - 41 for SANLC 2018, and class 10 - 31 for the SANLC 1990 and SANLC 2013-14).

Data sources

Department of Environmental Affairs, The Environmental Geographical Information System (E-GIS) website. Retrieved from https://www.environment.gov.za/mapsgraphics

Statistics South Africa, (2011). *Census spatial metadata (provincial boundaries)*. Retrieved from http://www.statssa.gov.za/?p=10341

Indicator status and recommendations for the way forward

Tier I

6.3 **INDICATOR 6.3:** NATIONAL CROP YIELD

Indicator definition

The yield of two major grain crops (wheat and maize) grown in South Africa.

Indicator rationale

Climate variability and climate change, together with a number of other factors, impact crop production and thus crop yield directly and indirectly. Rainfed crop production (i.e. non-irrigated) is more susceptible to climate variability and climate change than crops produced under irrigation.

Data visualisation

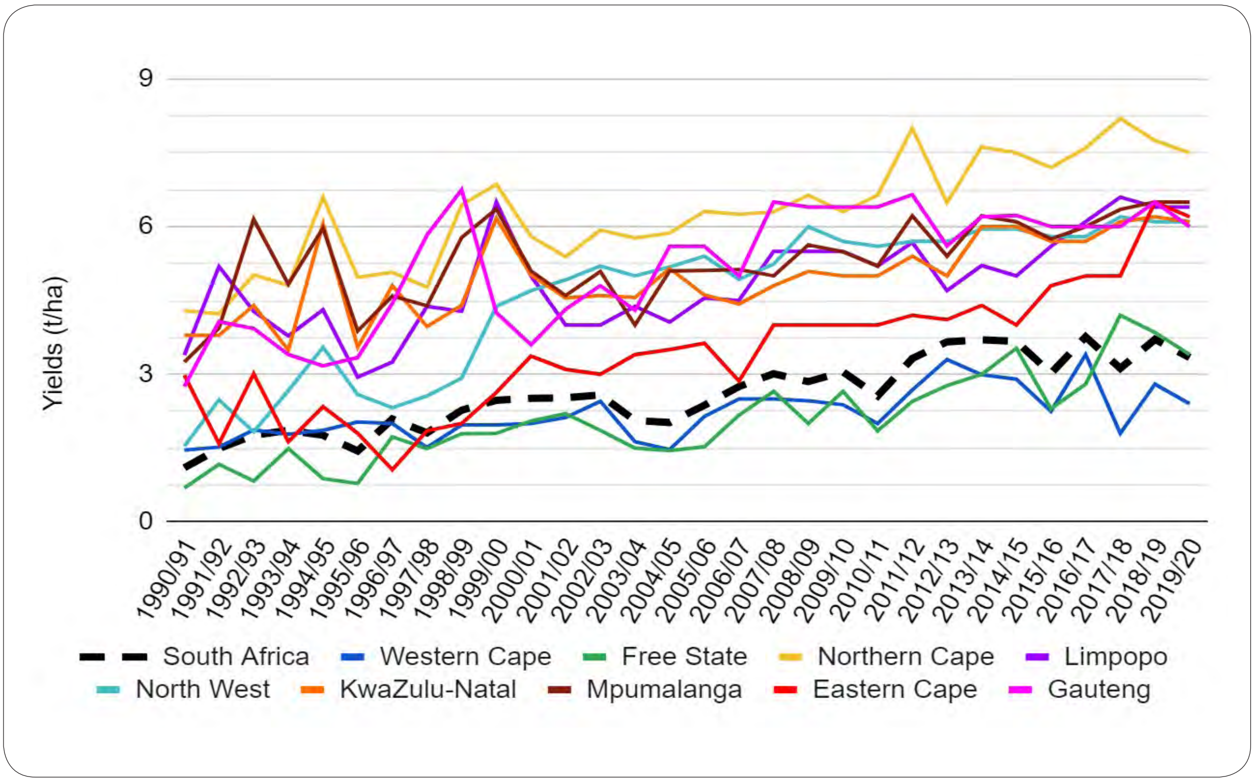


Figure 6.3.1: National (dashed line) and provincial (solid lines) wheat yields.

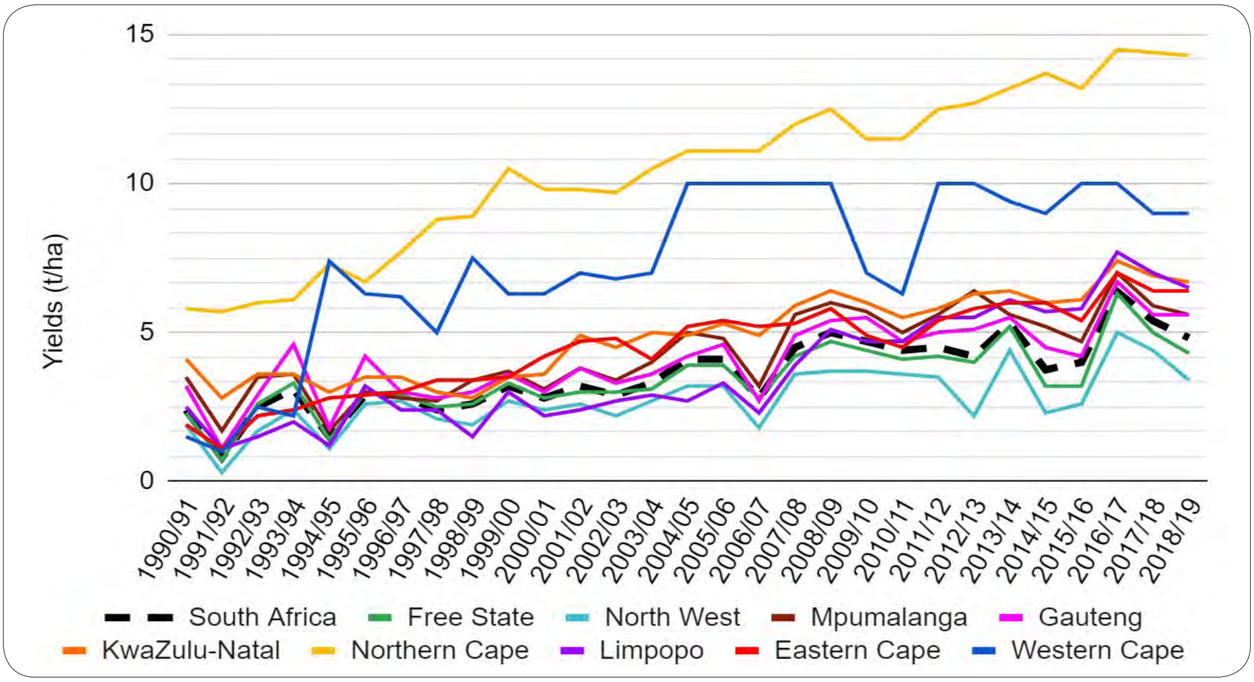


Figure 6.3.2: National (dashed line) and provincial (solid lines) maize (yellow and white combined) yields.

Analysis

National yields for both wheat and maize in South Africa have steadily increased from 1990. These increases in productivity align with the trend seen globally in commercial farming caused by improved farming practices and techniques and agricultural mechanisation.

The productivity of commercial wheat farming in South Africa increased by over 330% in 28 years. The national yield in 1990/01 of 1.1 tons of wheat produced per hectare planted increased to 3.71 t/ha in 2018/19. The Western Cape and Free State are generally the two provinces with the lowest yields, however, they are the two largest producers of wheat in South Africa, accounting for over 65% of the national production on average over the last five seasons (2014/15-2018/19). The majority of wheat grown in these two provinces is rainfed (non-irrigated) while in provinces such as the Northern Cape the majority of wheat production is grown under irrigation. Unfavourable climate conditions (including below average rainfall) during the winters of 2003 and 2004 likely contributed to the low productivity seen in the Western Cape and Free State during those years, causing the national average to decrease to its lowest point in six years.

The productivity of commercial maize (yellow and white) farming in South Africa increased by just under 200% between 1990/01 and the 2018/19 season. On average over the past five seasons (2014/15-2018/19) 80% of South Africa's maize was produced in three provinces: Free State (40%), Mpumalanga (23.6%) and North West (16.4%). A majority of the maize grown in these three provinces is reliant on rainfall as they are not irrigated. The yields achieved in Free State and North West tend to be lower than the national average, especially in more recent times. The Western Cape province experienced the largest increase in yields over the 28-year period, increasing by 450% although this only accounts for 0.3% of the national maize production and all is produced under irrigation.

Data

Table 6.3.1: National and provincial wheat yields (t/ha).

	South Africa	Western Cape	Free State	Northern Cape	Limpopo
1990/91	1.1	1.46	0.69	4.29	3.39
1991/92	1.49	1.52	1.17	4.23	5.19
1992/93	1.76	1.87	0.83	5.02	4.28
1993/94	1.86	1.78	1.49	4.81	3.78
1994/95	1.76	1.86	0.88	6.6	4.31
1995/96	1.44	2.03	0.78	4.97	2.94
1996/97	2.09	2	1.73	5.07	3.25
1997/98	1.81	1.51	1.49	4.77	4.38
1998/99	2.27	1.97	1.79	6.44	4.28
1999/00	2.47	1.97	1.8	6.86	6.5
2000/01	2.51	2	2.05	5.8	5
2001/02	2.52	2.12	2.2	5.39	4
2002/03	2.58	2.45	1.86	5.93	4
2003/04	2.06	1.63	1.5	5.77	4.38
2004/05	2.02	1.47	1.45	5.87	4.06
2005/06	2.37	2.14	1.526	6.31	4.55
2006/07	2.75	2.5	2.167	6.25	4.5
2007/08	3.01	2.5	2.651	6.3	5.5
2008/09	2.85	2.46	2	6.64	5.5
2009/10	3.05	2.38	2.65	6.3	5.5
2010/11	2.56	2	1.85	6.64	5.2
2011/12	3.32	2.68	2.45	8	5.68
2012/13	3.66	3.3	2.77	6.49	4.7
2013/14	3.7	2.99	3	7.62	5.21
2014/15	3.67	2.9	3.53	7.5	5
2015/16	3.02	2.25	2.3	7.2	5.6
2016/17	3.76	3.4	2.8	7.6	6.1
2017/18	3.12	1.8	4.2	8.2	6.6
2018/19	3.71	2.8	3.85	7.75	6.4
2019/20	3.34	2.4	3.4	7.5	6.4

	North West	KwaZulu-Natal	Mpumalanga	Eastern Cape	Gauteng
1990/91	1.54	3.79	3.25	2.98	2.75
1991/92	2.48	3.79	3.94	1.59	4.07
1992/93	1.83	4.4	6.15	3.01	3.93
1993/94	2.67	3.49	4.83	1.63	3.4
1994/95	3.55	6.06	5.97	2.34	3.17
1995/96	2.59	3.55	3.88	1.8	3.34
1996/97	2.32	4.8	4.59	1.06	4.44
1997/98	2.56	3.97	4.39	1.85	5.83
1998/99	2.92	4.4	5.78	2	6.75
1999/00	4.38	6.17	6.36	2.63	4.25
2000/01	4.7	5.02	5.1	3.37	3.6
2001/02	4.92	4.55	4.6	3.1	4.32
2002/03	5.2	4.6	5.09	3	4.8
2003/04	5	4.56	4	3.4	4.3
2004/05	5.18	5.15	5.1	3.5	5.6
2005/06	5.4	4.61	5.11	3.63	5.6
2006/07	4.93	4.43	5.13	2.86	5
2007/08	5.24	4.8	5	4	6.5
2008/09	6	5.09	5.63	4	6.4
2009/10	5.7	5	5.49	4	6.4
2010/11	5.6	5	5.2	4	6.4
2011/12	5.7	5.4	6.22	4.2	6.65
2012/13	5.7	5	5.4	4.11	5.61
2013/14	5.95	6	6.22	4.4	6.2
2014/15	5.95	6	6.1	4	6.23
2015/16	5.8	5.7	5.75	4.8	6
2016/17	5.8	5.7	6	5	6
2017/18	6.2	6.1	6.35	5	6
2018/19	6.1	6.2	6.5	6.5	6.5
2019/20	6.1	6.1	6.5	6.2	6

Table 6.3.2: National and provincial maize (yellow and white combined) yields (t/ha).

	South Africa	Western Cape	Free State	Northern Cape	Limpopo
1990/91	2.4	2.3	1.9	3.5	3.2
1991/92	0.8	0.7	0.3	1.7	1.1
1992/93	2.5	2.6	1.7	3.5	2.9
1993/94	3.1	3.3	2.4	3.6	4.6
1994/95	1.5	1.4	1.1	1.7	1.8
1995/96	2.9	3	2.6	3	4.2
1996/97	2.9	2.9	2.7	2.8	3
1997/98	2.4	2.5	2.1	2.7	2.8
1998/99	2.6	2.6	1.9	3.4	3
1999/00	3.2	3.3	2.7	3.7	3.6
2000/01	2.8	2.8	2.4	3.1	3
2001/02	3.2	3	2.6	3.8	3.8
2002/03	2.9	3	2.2	3.4	3.3
2003/04	3.3	3.1	2.7	4	3.6
2004/05	4.1	3.9	3.2	5	4.2
2005/06	4.1	3.9	3.2	4.8	4.6
2006/07	2.8	2.8	1.8	3.2	2.7
2007/08	4.5	4.2	3.6	5.6	4.9
2008/09	5	4.7	3.7	6	5.4
2009/10	4.7	4.4	3.7	5.7	5.5
2010/11	4.4	4.1	3.6	5	4.7
2011/12	4.5	4.2	3.5	5.6	5
2012/13	4.2	4	2.2	6.4	5.1
2013/14	5.3	5.2	4.4	5.6	5.5
2014/15	3.75	3.2	2.3	5.2	4.5
2015/16	4	3.2	2.6	4.7	4.2
2016/17	6.37	6.3	5	7	6.7
2017/18	5.39	5	4.4	5.9	5.6
2018/19	4.82	4.3	3.4	5.6	5.6

	North West	KwaZulu-Natal	Mpumalanga	Eastern Cape	Gauteng
1990/91	4.1	5.8	2.5	1.9	1.5
1991/92	2.8	5.7	1.1	1.1	1
1992/93	3.6	6	1.5	2.2	2.5
1993/94	3.6	6.1	2	2.4	2.2
1994/95	3	7.3	1.2	2.8	7.4
1995/96	3.5	6.7	3.2	2.9	6.3
1996/97	3.5	7.7	2.4	3	6.2
1997/98	3	8.8	2.4	3.4	5
1998/99	2.8	8.9	1.5	3.4	7.5
1999/00	3.5	10.5	3	3.5	6.3
2000/01	3.6	9.8	2.2	4.2	6.3
2001/02	4.9	9.8	2.4	4.7	7
2002/03	4.5	9.7	2.7	4.8	6.8
2003/04	5	10.5	2.9	4.1	7
2004/05	4.9	11.1	2.7	5.2	10
2005/06	5.3	11.1	3.3	5.4	10
2006/07	4.9	11.1	2.3	5.2	10
2007/08	5.9	12	3.9	5.3	10
2008/09	6.4	12.5	5.1	5.8	10
2009/10	6	11.5	4.7	4.9	7
2010/11	5.5	11.5	4.7	4.5	6.3
2011/12	5.8	12.5	5.5	5.4	10
2012/13	6.3	12.7	5.5	5.8	10
2013/14	6.4	13.2	6.1	6	9.4
2014/15	6	13.7	5.7	6	9
2015/16	6.1	13.2	5.8	5.4	10
2016/17	7.4	14.5	7.7	7	10
2017/18	6.9	14.4	7	6.4	9
2018/19	6.7	14.3	6.5	6.4	9

Data notes

There are a plethora of factors that can influence crop yields, ranging from international markets to individual farmers' decisions. It is, therefore, difficult to definitively single out the influence of climate variability and climate change when looking solely at the crop yield data.

Data sources

Grain South Africa, (1990-2019). Production Reports. Retrieved from https://www.grainsa.co.za/pages/industry-reports/production-reports

Indicator status and recommendations for the way forward

Tier I

Comment: It may be worth exploring this indicator further, looking into including or substituting aspects such as area planted and consumptions.

INDICATOR 6.4: GREENHOUSE GAS EMISSIONS FROM AGRICULTURE

6.4

Indicator definition

This indicator tracks greenhouse gas emissions from agriculture activities.

Indicator rationale

In South Africa, agriculture is the main source of emissions in agriculture, forestry and land use change. The main driver of agriculture emissions is livestock through digestive processes in animals (enteric fermentation), livestock manure and to a lesser extent the use of synthetic fertilisers. A shift to best practice environmental land-use management (e.g. organic farming, reduced tillage, use of biodigesters), more efficient use of fertilisers and dietary changes, including more moderate meat consumption, could help reduce emissions.

Data visualisation

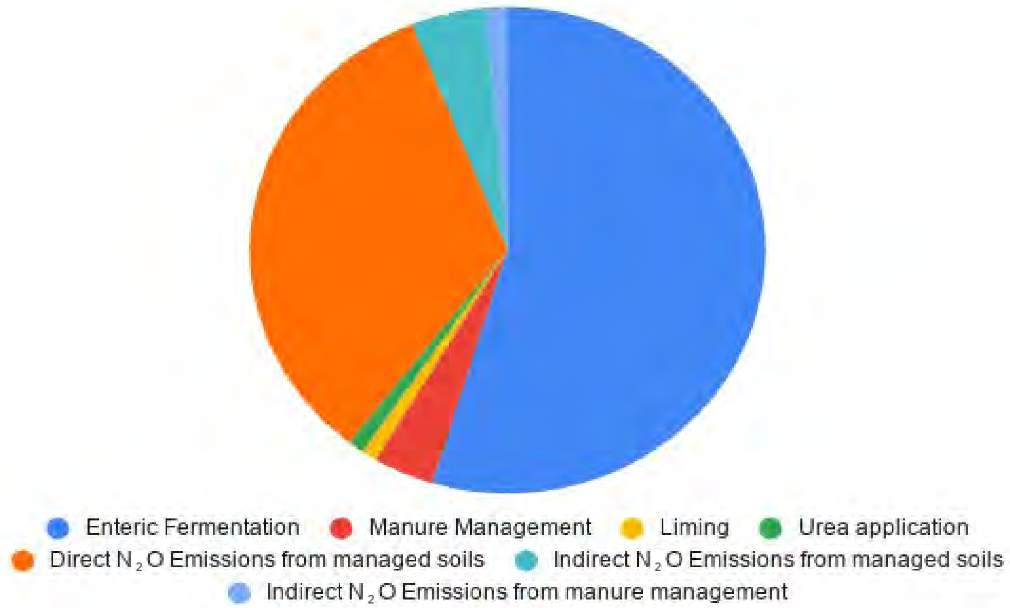


Figure 6.4.1: Contributing sources of agriculture greenhouse gas (GHG) emissions as percentage shares.

Analysis

The main driver of greenhouse gas emissions is the livestock population, through enteric fermentation which is the main source of agriculture emissions. Direct N_2O emissions from managed soils is also a significant contributor. This includes from crop residues and emissions from manure produced in the field (as opposed to manure that is collected and accounted for within 'manure management' emissions data).

Data

Table 6.4.1: Contributing sources of agriculture GHG emissions as percentage shares.

Source of emissions	
Enteric fermentation	54.7%
Manure management	3.8%
Liming	1.0%
Urea application	1.0%
Direct N_2O emissions from managed soils	33.4%
Indirect N_2O emissions from managed soils	4.7%
Indirect N_2O emissions from manure management	1.3%

Data notes

Emissions data are extracted from the National Inventory Greenhouse Gas Report. The Report uses the IPCC 2006 Guidelines. Emissions from land use change (Subcategory 3.B), from biomass burning (Subcategory 3.C), and harvested wood products (Subcategory 3.D) are not included in the data used for this indicator. Some of these emissions may be from agriculture, but it is not possible to separate these out of the existing data.

Enteric fermentation emissions from poultry were not estimated in the National Inventory Greenhouse Gas Report as the amount produced is considered negligible (IPCC, 2006).

Data sources

Department of Environmental Affairs, 2017, GHG National Inventory Report: South Africa 2000-2015. Retrieved from https://www.environment.gov.za/sites/default/files/reports

Indicator status and recommendations for the way forward

Tier 1

INDICATOR 6.5: CONSERVATION AGRICULTURE

6.5

Indicator definition

The proportion of crop agriculture area applying a conservation agriculture (CA) approach.

Indicator rationale

Conservation agriculture is based on three principles which include minimal soil disturbances, continuous soil cover and crop rotation. This approach is yielding positive results in terms of climate change, through increased sequestration of carbon, as well as increased productivity.

Data visualisation

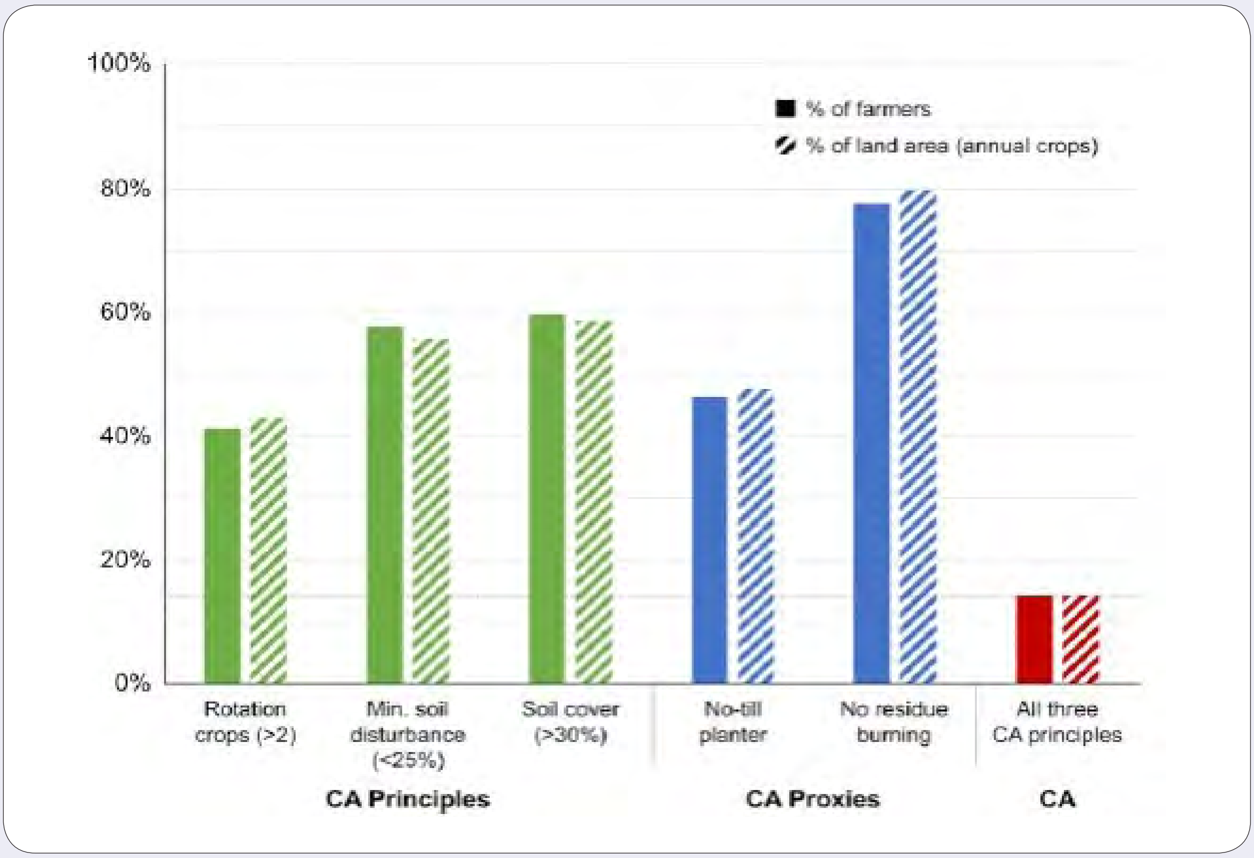


Figure 6.5.1: Percentage of commercial farmers that apply conservation agriculture practices (Source: Findlater *et al.*, 2019).

Figure 6.5.2: Percentage of commercial farmers in each area labelled, that apply at least one conservation agriculture practice (Source: Findlater *et al.*, 2019).

Analysis

There is a low conservation agriculture comprehensive adoption rate amongst commercial grain producers, with only 14% of the survey's 441 respondents adopting all three CA principles and a no-till planter.

Data

Table 6.5.1: Percentage of commercial farmers that apply conservation agriculture practices (Source: Findlater *et al.*, 2019).

High SC (> 30%)	Low SD (< 25%)	Rot. Crops (2+)	Rot. Crops (3+)	No-Till Planter	CA (2+)	CA (3+)	CA (2+ & NT)	CA (3+ & NT)
75.7%	55.3%	94.2%	68.9%	75.7%	41.7%	29.1%	35.9%	27.2%

Variable	Description
High SC (> 30%)	More than 30% of soil surface covered with plant residue after planting
Low SD (< 25%)	Less than 25% of soil surface disturbed after planting
Rot. Crops (2+)	2 or more crops included in rotation
Rot. Crops (3+)	3 or more crops included in rotation
No-Till Planter	Use a no-till planter (tine or disc)
CA (2+)	Adopted the three CA principles (with 2 or more crops in rotation)
CA (3+)	Adopted the three CA principles (with 3 or more crops in rotation)
CA (2+ & NT)	Adopted the three CA principles and use a no-till planter (with 2 or more crops in rotation)
CA (3+ & NT)	Adopted the three CA principles and use a no-till planter (with 3 or more crops in rotation)

Data notes

The graph and analysis is based on a once-off national survey with 441 respondents and focuses on commercial grain farming only. This is thus a case study example, and is not nationally representative for the agricultural sector as a whole nor for the entire commercial grain farming sector.

Data sources

Findlater, K. M., Kandlikar, M. and Satterfield, T., 2019. Misunderstanding conservation agriculture: Challenges in promoting, monitoring and evaluating sustainable farming. Environmental Science & Policy 100: 47-54

Indicator status and recommendations for the way forward

Tier 3

Currently showing: Commercial grain farming case study.

Required: The set-up of regular data collection (surveys) and analysis.

Comment: This study could form the inspiration for the development of a conservation agriculture indicator. The study presented here only focuses on commercial grain producers and making it applicable beyond grain would require further work around survey design and analysis.

6.6 INDICATOR 6.6: BIODIVERSITY-RELATED EMPLOYMENT

Indicator definition

The proportion of jobs related to biodiversity, as reported in the National Biodiversity Assessments (NBAs).

Indicator rationale

In South Africa biodiversity-related employment is located mainly in rural areas. Biodiversity-related employment can play an important role in labour absorption and in inclusive growth for rural sectors that show declining employment, for example in agriculture and mining. The number of biodiversity-related jobs provides an estimate of the socio-economic benefits of biodiversity. It is important to maintain some non-extractive biodiversity jobs in supporting climate adaptation measures to increase resilience in rural areas through restoration and protection of ecological function. Therefore, natural resource extraction will need to be sustainably managed in order to ensure these benefits continue or grow. Climate change brings risks and opportunities to employment and livelihoods related to biodiversity.

Data visualisation

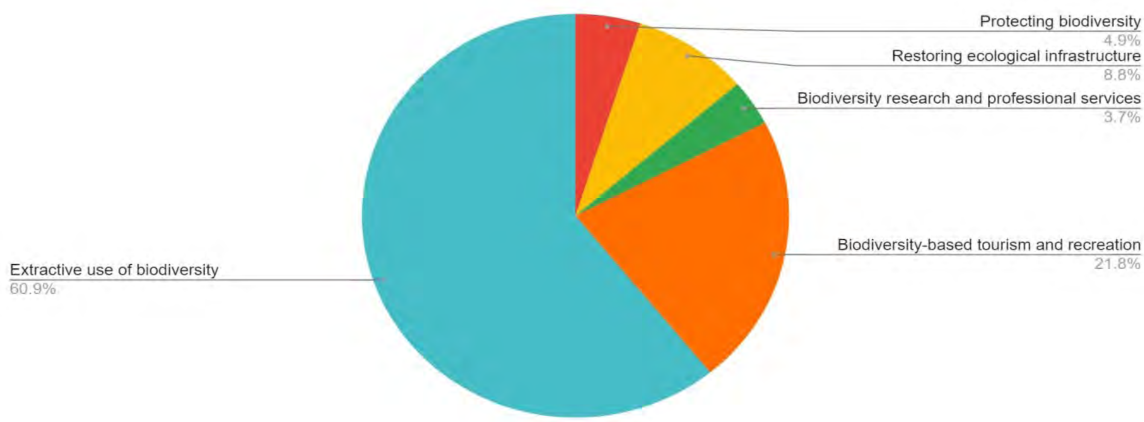


Figure 6.6.1: Share of biodiversity-related employment in 2018.

Analysis

Based on 2014 and 2017 information, a total of 418 539 biodiversity-related jobs were counted. Of these, 17% work on conserving biodiversity, and 83% are engaged in using biodiversity (SANBI, 2018). In 2018, 61% of the jobs depended on the direct extraction or consumption of biodiversity, either for profit or subsistence. These include game ranching and hunting, rangeland agriculture, harvesting of wild indigenous resources, bio-trade, cultivation of indigenous species, processing or manufacturing of products based on indigenous resources, and bioprospecting. Long-term persistence of biodiversity and continued socio-economic benefits relies on appropriate management of these activities.

Data

Table 6.6.1: Share of biodiversity-related employment in 2018.

Biodiversity-related employment	Number of jobs
Protecting biodiversity	20 376
Restoring ecological infrastructure	36 420
Biodiversity research and professional services	15 193
Biodiversity-based tourism and recreation	90 252
Extractive use of biodiversity	252 298

Data notes

This is an initial assessment, so no earlier figures can be included.

The data uses administrative data from organisations involved in biodiversity-related activities, existing sector estimates and survey data from the National Statistical System. The five sub-categories of biodiversity employment identified in the data are jobs that are: 1) involved in conservation of the country's biodiversity, such as the management of protected areas; 2) aimed at restoring the functioning of ecosystems to improve the provision of benefits to people, such as removing invasive alien plants to improve water supply, or restoring wetlands to improve water quality and prevent flooding; 3) contributing to knowledge of biodiversity, forming the foundation for management and sustainable use, such as biodiversity-related work in universities and museums; 4) dependent on the enjoyment of biodiversity such as nature-based tourism, or some adventure sports, but not the consumptive use of biodiversity; 5) dependent on the direct extraction or consumption of biodiversity, such as hunting or fishing.

Data sources

South African National Biodiversity Institute. 2019. National Biodiversity Assessment 2018. South African National Biodiversity Institute, an entity of the Departmentof Environment, Forestry and Fisheries. Retrieved from http://hdl.handle.net/20.500.12143/6362

Indicator status and recommendations for the way forward

Tier 1

6.7

INDICATOR 6.7: BIODIVERSITY AND ECOSYSTEMS, THREAT LEVEL AND PROTECTION STATUS

Indicator definition

The threat level and protection status of species and ecosystems, as reported in the National Biodiversity Assessments (NBAs).

Indicator rationale

Biodiversity is an important national resource for food, shelter, clothing, healing properties and enjoyment, for now and for future generations. It is under threat from climate change, human activities, and alien invasive organisms. The level of threat to ecosystems and to species is an indicator of the effort and urgency necessary to address these threats. The national protected area system was established to conserve a representative sample of the country's biodiversity and to maintain key ecological processes across the landscape and seascape. The level of ecosystem and species protection is an indicator of representation and it highlights where more protection is needed.

Data visualisation

Figure 6.7.1: Levels of threat status and protection level of ecosystems and species, as reported in the National Biodiversity Assessment 2018 (Source: SANBI 2019).

Analysis

According to the National Biodiversity Assessment 2018, 14% of local plant species and 12% of indigenous animal species are threatened. Estuaries and inland wetland ecosystem types are the most threatened of the ecosystem types; wetland and river ecosystem types have the lowest levels of protection. Of all the country's ecosystems, estuaries and inland wetlands are the most at risk, with more than half of these ecosystem types classified as critically endangered. Proportionally, of all species, freshwater fish and amphibian species are endangered or critically endangered. Approximately two-thirds of the ecosystems represented within the current network are protected areas in South Africa. This means that nearly a third of the types of ecosystems are not protected.

Data

Data tables are not accessible.

Data notes

The NBA has four headline indicators, providing information on the threat status and protection level of ecosystems and species. The threat status indicators use the established IUCN Red List of Species and Red List of Ecosystems assessment frameworks. The risk of extinction (species) or collapse (ecosystems) is evaluated across all realms and for taxonomic groups for which sufficient data exists. The protection level indicators reflect how well our species and ecosystem types are represented in the protected area network.

Data Sources

South African National Biodiversity Institute. 2019. *National Biodiversity Assessment 2018*. South African National Biodiversity Institute, an entity of the Departmentof Environment, Forestry and Fisheries. Retrieved from http://hdl.handle.net/20.500.12143/6362

Indicator status and recommendations for the way forward

Tier 2

Currently showing: Analysis and figures from the National Biodiversity Assessment (NBA).

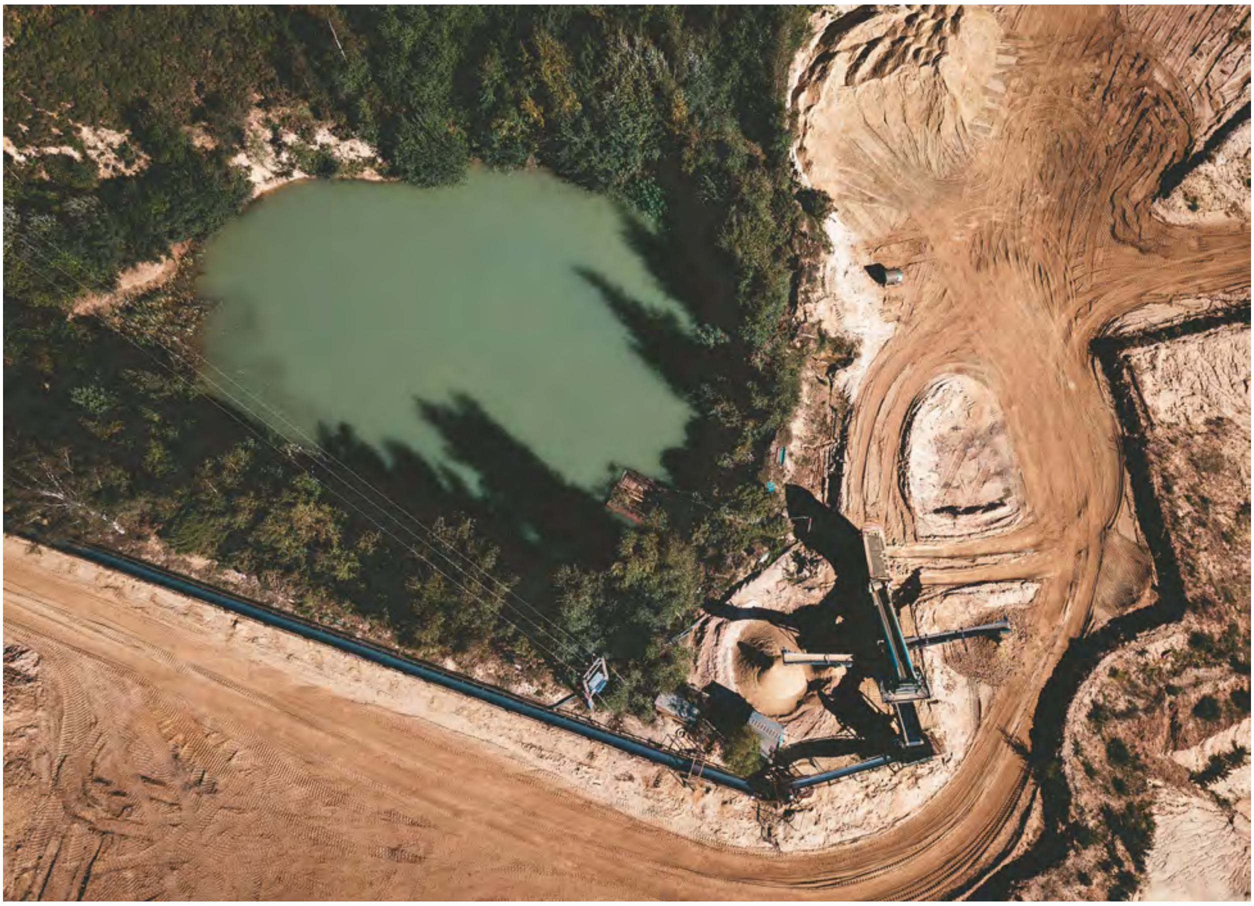
INDICATOR 6.7.1: BIODIVERSITY AND ECOSYSTEM KEY PRESSURES

Indicator definition

The key pressures on biodiversity in each natural realm (terrestrial, inland aquatic, marine, estuarine) and cross-realm (the coast and sub-Antarctic territory), and their impacts - as reported in the National Biodiversity Assessments (NBAs).

Indicator rationale

There is evidence of negative impacts of climate change in all realms. Many species are threatened with a high risk of extinction in the near future. These threatened species are classified as Critically Endangered, Endangered or Vulnerable, based on a conservation assessment (Red List), using a standard set of criteria developed by the IUCN for determining the likelihood of a species becoming extinct (SANBI 2019). Meta-analysis of the country's database of threatened species and expert opinion provides an assessment of the key pressures (SANBI 2019).



Data visualisation

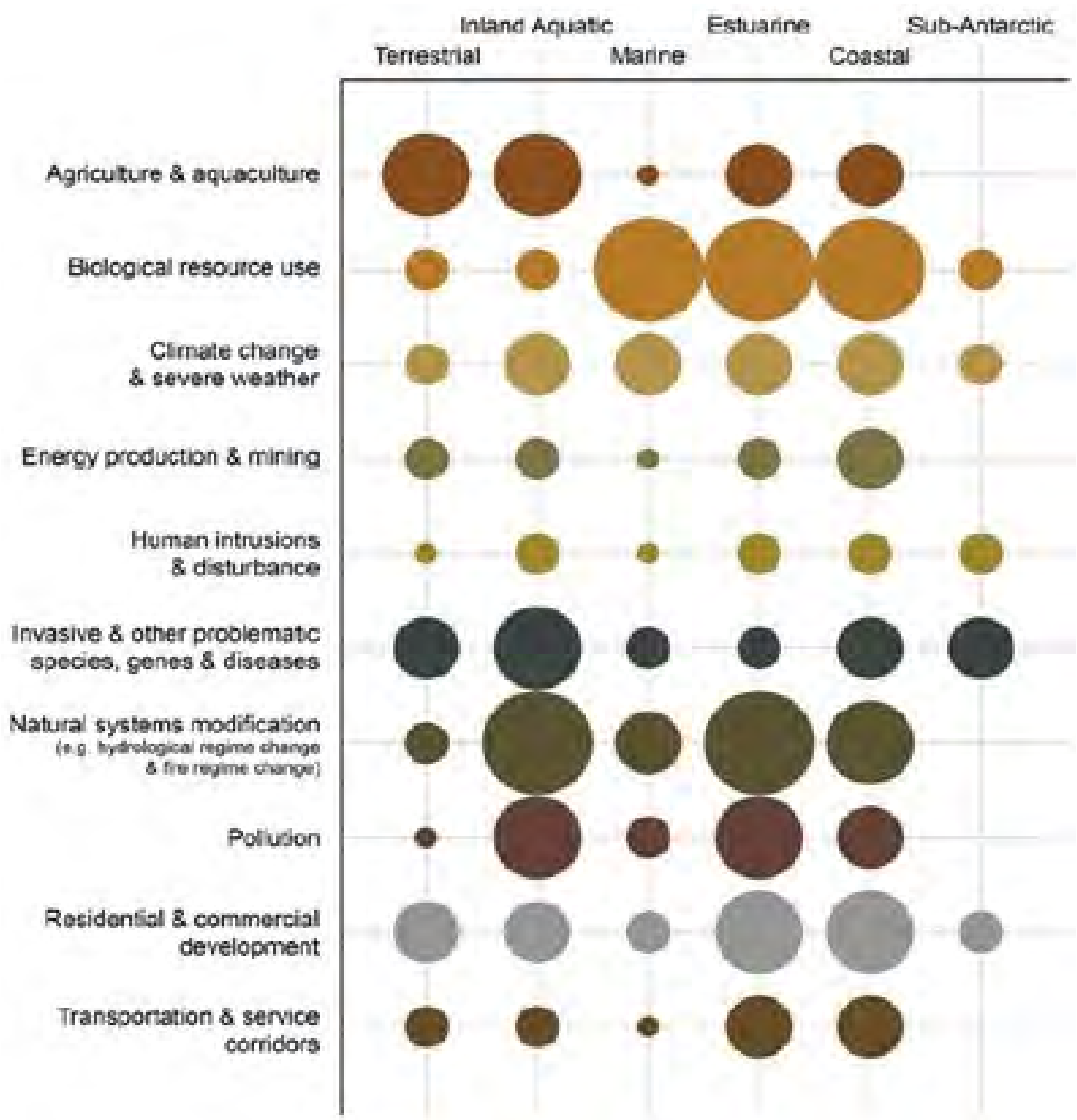


Figure 6.7.1.1: Level of threat posed by climate change and severe weather to natural realms, as assessed in the National Biodiversity Assessment 2018 (Source: SANBI 2019).

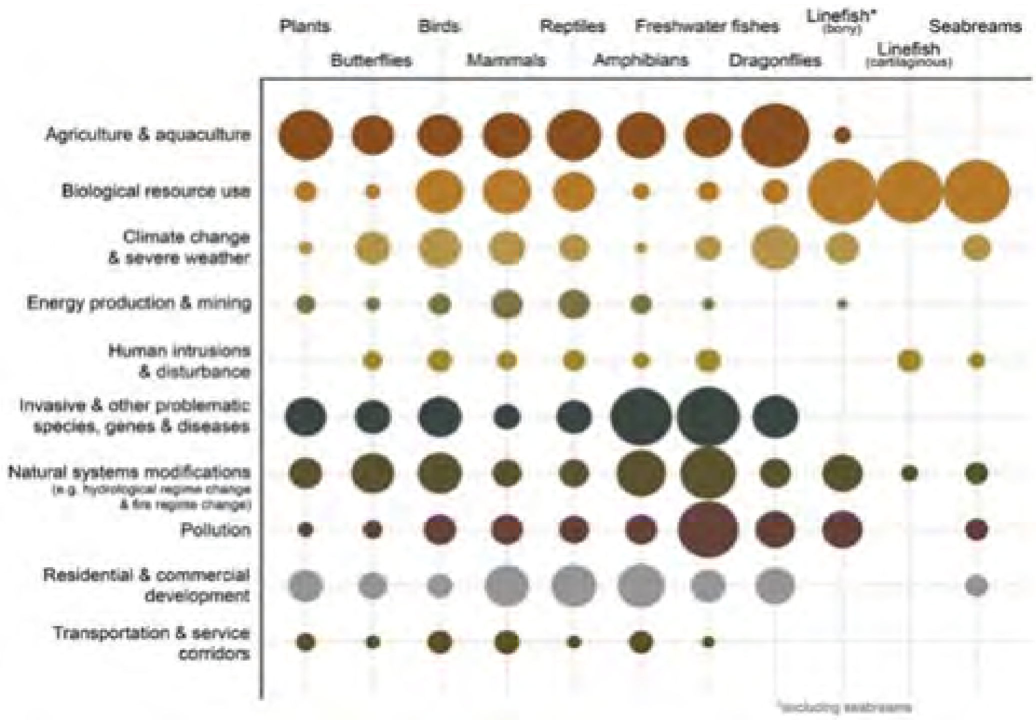


Figure 6.7.1.2: Level of threat posed by climate change and severe weather to species groups, as assessed in the National Biodiversity Assessment 2018 (Source: SANBI 2019).

Analysis

Of all the species groups that have been fully assessed in South Africa, freshwater fish are the most threatened. South Africa has 118 freshwater fish species, of which half are endemic (found nowhere else in the world). Key pressures on freshwater fish include predation by alien invasive fish and habitat degradation. Unsustainable harvesting of biological resources like fish is the dominant key pressure in estuarine marine and coastal realms. Climate change and severe weather show moderate pressure on ecosystems and biodiversity.

Data

Data tables are not accessible.

Data notes

The assessment of key pressures on biodiversity in each realm is based on a meta-analysis of the threatened species database and expert opinion. The size of the bubbles indicates the relative importance of each pressure class.

Taxa of Conservation Concern (ToCC) are species and subspecies that are assessed according the IUCN Red List criteria as Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Data Deficient (DD) or Near Threatened (NT). Detailed information on the pressures impacting these taxa has been captured during the Red List assessment processes. Throughout the NBA, reference to the impact of a particular pressure on a taxonomic group is determined from the proportion of ToCC impacted by that pressure.

Data Sources

South African National Biodiversity Institute. 2019. *National Biodiversity Assessment 2018*. South African National Biodiversity Institute, an entity of the Departmentof Environment, Forestry and Fisheries. Retrieved from http://hdl.handle.net/20.500.12143/6362

Indicator status and recommendations for the way forward

Tier 2

Currently showing: Analysis and figures from the National Biodiversity Assessment (NBA).

INDICATOR 6.8: LEAF AND BLOOM DATE

6.8

Indicator definition

The evidence of small shifts in climate through long-term records of leaf and bloom dates.

Indicator rationale

Leaf and bloom dates for plants are highly sensitive to climate. Many plants are dormant during the cooler temperatures of winter and sprout leaves or flower blooms only once temperatures are above a threshold value. The timing of annual recurring plant biological events is highly sensitive to climate perturbations. A shift in seasonal warming may shift the timing of threshold temperatures required for bloom. A change in seasonal flowering is good and widely visible evidence of small changes in climate and it can be tracked over a number of years and decades. Disruptions in the timing of leaf and bloom events can have a variety of impacts on the economy and agriculture industry, particularly crops sensitive to temperature and precipitation such as citrus, which is the largest fruit industry in South Africa.

Data visualisation

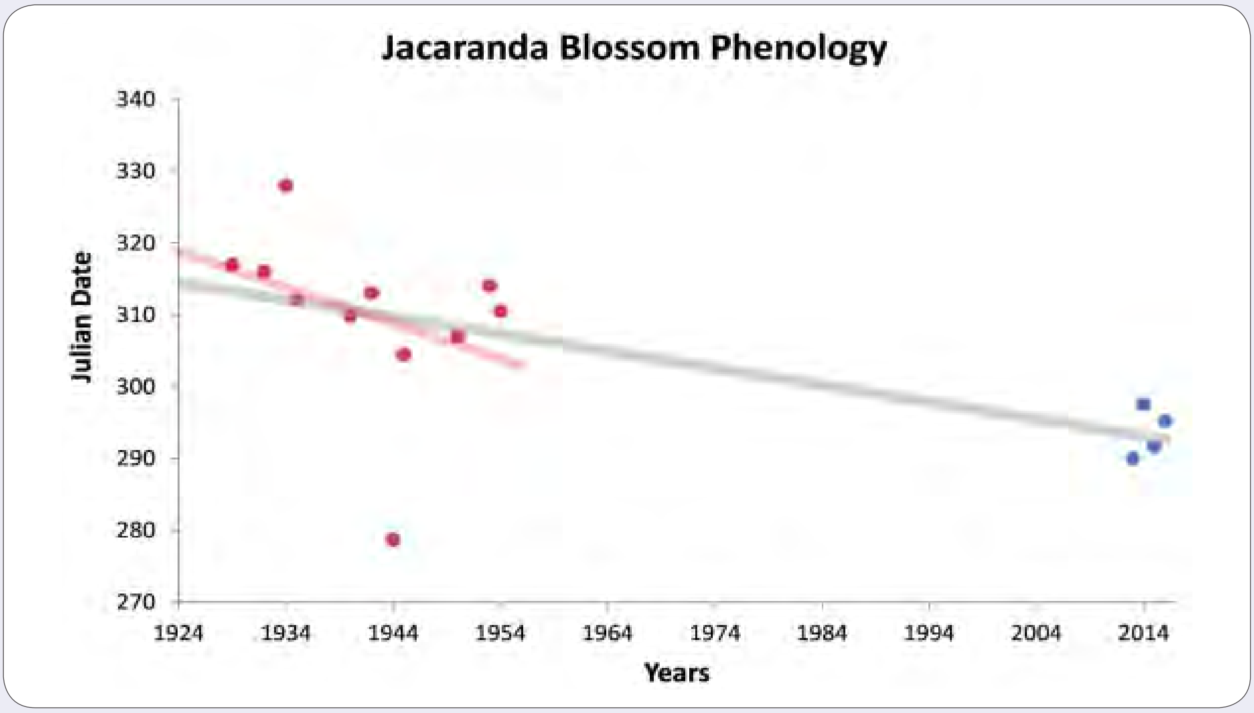


Figure 6.8.1: Jacaranda blossom phenological shift documented in newspaper records for the period 1924-1954 (red) and composite record for the period 1924-2016 (grey) for Gauteng Province, South Africa. (Source: Mahlangu and Fitchett 2019).

Analysis

Preliminary findings are that there is a shift in Jacaranda bloom dates to earlier in the year.

Data

Please see the indicator status section below. None.

Data notes

The NBA has four headline indicators, providing information on the threat status and protection level of ecosystems and species. The threat status indicators use the established IUCN Red List of Species and Red List of Ecosystems assessment frameworks. The risk of extinction (species) or collapse (ecosystems) is evaluated across all realms and for taxonomic groups for which sufficient data exists. The protection level indicators reflect how well our species and ecosystem types are represented in the protected area network.

Data Sources

Mahlangu, M. N., and Fitchett, J. M., 2019. Climate change threats to a floral wedding: Threats of shifting phenology to the emerging South African wedding industry. *Bulletin of Geography. Socio-economic Series, 45*(45), 7-23.

Indicator status and recommendations for the way forward

Tier 3

Comment: Since the initial analysis in the 2019 publication on Jacaranda phenology, a more complete time series database has been developed and subjected to statistical analysis. This analysis includes an investigation of the seasonal incidence of climate phenomena to better understand potential causes of trends in the phenology data. This second analysis has been submitted to the South African Journal of Science, and based on previous experience the author(s) anticipate that publication can reasonably be anticipated for mid-2020.

INDICATOR 6.9: AVERAGE ANNUAL BURNED AREA BY PROVINCE

Indicator definition

The annual extent of fire burned areas in South Africa, disaggregated to provincial scale.

Indicator rationale

There is some evidence that increasing temperatures and, in some cases, decreasing rainfall, can contribute to higher fire danger and increased fire intensity. The extent of fires depends on a number of factors: climatic (air temperature, humidity, rainfall, winds); human activity-related (incidence of intentional fires, ability to control wildfires); fire history related (time since the last burn, fuel load accumulation); land cover/land use related (nature of the vegetation); location-related (presence of natural and man-made firebreaks). While fires are generally hard to attribute to climate, it is clear that monitoring changes and trends in fire will provide a useful index of rural and semi-rural/urban edge landscape change.

Data visualisation

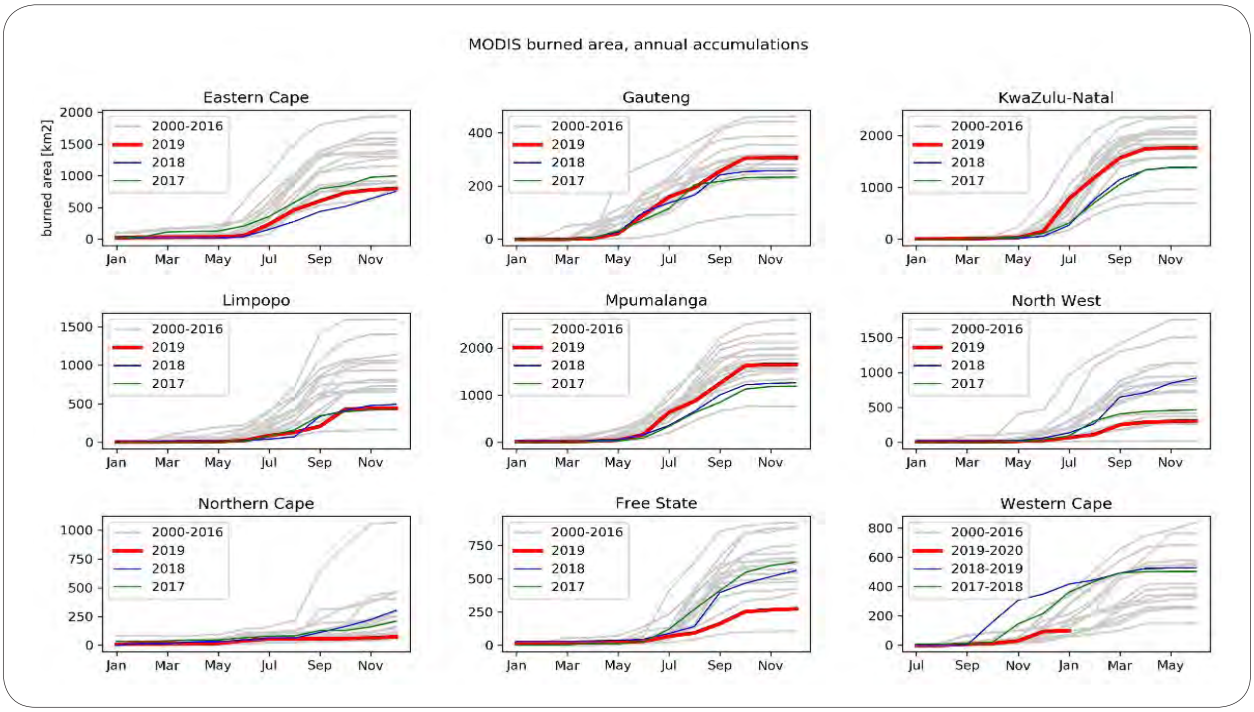


Figure 6.9.1: Annual accumulations of burned areas within provinces. Fire season in the Western Cape is in summer (Nov-Apr) and the rest of the country in late winter (Jun-Sep), hence a different x-axis for the Western Cape.

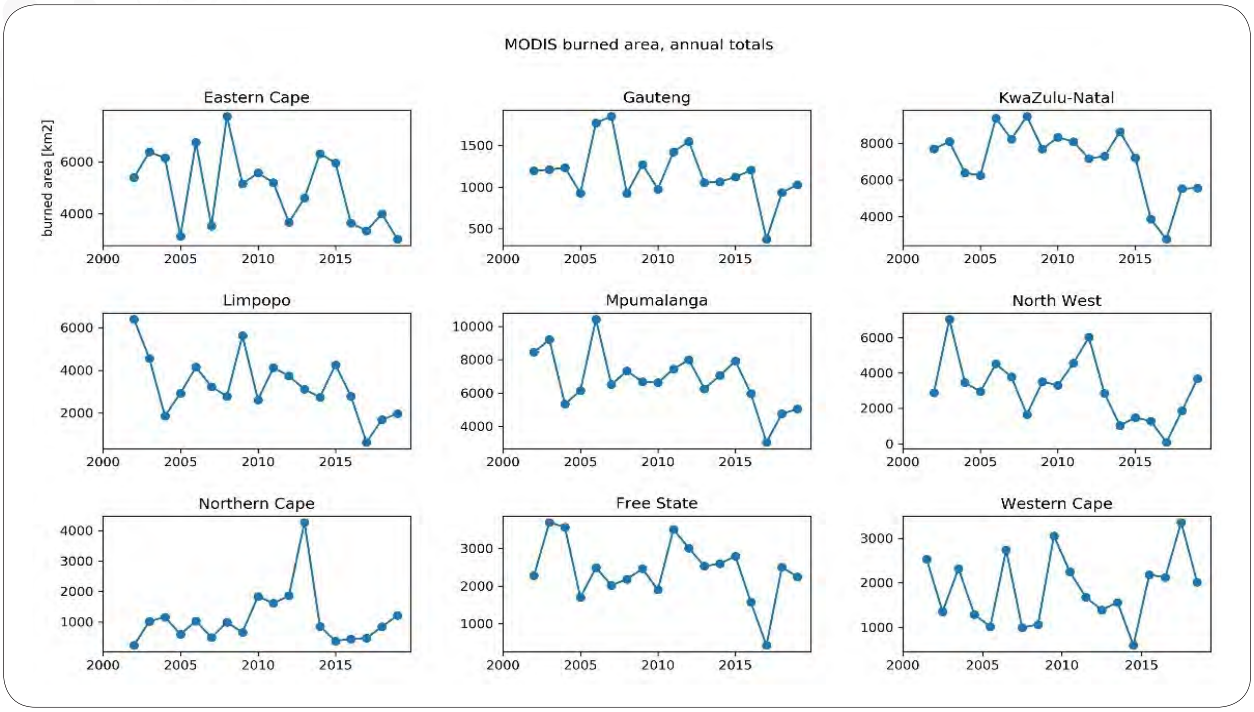


Figure 6.9.2: Total area burned per year within provinces.

Analysis

The burn area shows clear seasonality, with the majority of fires occurring during the dry season. As a result, the fire season is different in the western part of the country, where there is a winter rainfall regime, and the central and eastern part of the country, where there is a summer rainfall regime.

The year-to-year variability and long-term trends in total burned area can potentially be interpreted as a result of climate change, but only after a careful consideration of other time- varying factors. Of significance here is the fact that some factors can compensate. For example, higher temperatures and higher winds can drive more extensive fires. But on the other hand, a multi-year drought can prevent build-up of fireload, resulting in reduction of fire extent.

In the last five years, the extent of the burned area in all the provinces apart from the Western Cape, was lower than in the pre-2015 period, giving a signature of a downward trend. The lowest extent of burning recorded in 2017, and the 2016-2017 low is likely due to low fire load following the 2015-2016 El Niño-driven drought. Larger extents of fire were recorded since then in the eastern provinces. The extent of fires remain low in the Eastern Cape, however, likely due to continuing drought in that province.

In the Western Cape, the largest fires were recorded in the 2017-2018 season, likely reflecting the 2017 Knysna fire, and this is the only province that shows a signature of an upward trend.

Data

Data table for annual accumulations not possible as too big.

Table 6.9.1: Annual total burned areas within provinces. Western Cape year is from July- June to accommodate its fire season which occurs in the summer.

	Eastern Cape	Gauteng	KwaZulu-Natal	Limpopo	Mpuma-langa	North West	Northern Cape	Free State		Western Cape
2000-12-31	80	0	0	165	17	133	1064	123		
2001-12-31	21 569	4 783	30 799	25 552	33 779	11 557	923	9 117	2001-06-30	10 113
2002-12-31	25 496	4 837	32 394	18 210	36 798	28 171	4 090	14 793	2002-06-30	5 408
2003-12-31	24 594	4 931	25 563	7 466	21 310	13 853	4 645	14 273	2003-06-30	9 277
2004-12-31	12 563	3 712	24 996	11 706	24 559	11 795	2 385	6 792	2004-06-30	5 162
2005-12-31	26 979	7 074	37 494	16 611	41 695	18 092	4 122	9 979	2005-06-30	4 076
2006-12-31	14 102	7 395	32 915	12 949	26 041	15 112	1 974	8 081	2006-06-30	10 963
2007-12-31	31 009	3 696	37 913	11 160	29 288	6 613	3 945	8 743	2007-06-30	3 995
2008-12-31	20 609	5 089	30 777	22 473	26 691	14 031	2 645	9 840	2008-06-30	4 256
2009-12-31	22 279	3 901	33 291	10 489	26 474	13 235	7 346	7 611	2009-06-30	12 212
2010-12-31	20 768	5 680	32 370	16 510	29 759	18 223	6 470	14 038	2010-06-30	8 993
2011-12-31	14 656	6 187	28 690	14 929	31 954	24 098	7 445	12 041	2011-06-30	6 714
2012-12-31	18 421	4 206	29 182	12 469	24 994	11 434	17 089	10 123	2012-06-30	5 578
2013-12-31	25 260	4 250	34 503	10 972	28 217	4 128	3 429	10 398	2013-06-30	6 243
2014-12-31	23 816	4 483	28 846	17 032	31 648	5 917	1 505	11 187	2014-06-30	2 392
2015-12-31	14 575	4 806	15 425	11 152	23 858	5 109	1 778	6 278	2015-06-30	8 737
2016-12-31	13 394	1 498	11 060	2 533	12 163	312	1 892	1 696	2016-06-30	8 483
2017-12-31	15 976	3 737	22 092	6 778	19 015	7 445	3 362	10 015	2017-06-30	13 433
2018-12-31	12 074	4 117	22 227	7 885	20 160	14 713	4 867	9 003	2018-06-30	8 070
2019-12-31	12 793	4 888	28 192	7 059	26 465	4 915	1 199	4 392	2019-06-30	8 441
2020-12-31	16	3	74	15	45	6	33	1	2020-06-30	1 601

Data notes

Total burned area index is derived from MODIS Fire product and expresses the extent of all fires that occurred within a particular period.

The nature of the data and its spatial resolution (500m) is adequate for province and country- level synthetic analyses, data freely available, regularly updated, covering a relatively long period of time (thus suitable for trend analysis).

Data Sources

Giglio, L., Justice, C., Boschetti, L., Roy, D., 2015. *MCD64A1 MODIS/Terra+Aqua Burned Area Monthly L3 Global 500m SIN Grid V006* [Data set]. NASA EOSDIS Land Processes DAAC. Retrieved from https://doi.org/10.5067/MODIS/MCD64A1.006

Indicator status and recommendations for the way forward

Tier I

ANALYSIS AND REFLECTION ON INDICATORS IN THE SUSTAINABLE RURAL AND SEMI-RURAL LANDSCAPES NARRATIVE

For some agricultural system yields, such as for wheat and maize as reported in Indicator 6.3, a steady increase can be observed, despite the widespread and intense drought reported on in the water and development narrative Indicator 3.1. Improvements in farming practices and techniques have potentially played a role, compensating for the impacts of drought, though such attribution will require further investigation.

Case study Indicator 6.5 indicates that conservation agriculture plays a limited role in farming practices, though no nationally representative conclusion can be made at this point. The decrease in crop agricultural land use area, observed for all provinces except KwaZulu-Natal in Indicator 6.2, could be driven by a wide range of factors, and requires further investigation. As does the general interplay between yields, crop area, drought and farming practices.

Biodiversity-related jobs are important in semi-rural and rural areas, whether relating to direct extraction or consumption of biodiversity or jobs relating to conservation of biodiversity-related tourism. The biodiversity-related employment Indicator 6.6 is a snapshot in time (2018), and continued monitoring of these employment numbers can provide important information on how such employment numbers fluctuate as climate change and environmental degradation potentially threaten their basis – or provide new opportunities.

Fires play an important role in the habitat vitality and renewal of South African ecosystems. Trends observed in the annual average burned area per province (indicator 6.9) indicate an overall decrease in the extent of burned areas over the last five years. This is interesting in the context of the drought conditions reported on in Indicator 3.1, and points to the complex interconnections between fuel load, meteorological conditions, fire management practices and land use changes. Fire danger index Indicator 6.9.1, when completed under future iterations of this report, will complement this, as it will provide an idea of any changes in the meteorological conditions that are favourable to fires.

The Sustainable Rural and Semi-Rural Landscapes Narrative and the related indicators are a starting point. They aim to shine a light on the complexities that shape these areas and provide a point of departure for tracking changes across social, economic and environmental elements in the rural and semi-rural landscape. However, a lot of work is needed to create a more complete picture, including the addition and weaving in of indicators relating to factors such as land tenure, land redistribution, employment, economic opportunity and service delivery. Further to this, there is a need to establish a clear definition of rural and semi-rural areas, and to then spatially align the indicators to this so that they each represent the same geographic area.

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CONCLUSION

REFLECTIONS ON CONCEPTUAL FRAMING AND APPROACH

Approaches to understanding, tracking and reporting on complex interlinked systems, such as those involved in climate change are evolving. There are, as a result, multiple ways of approaching this challenge. For the purposes of developing indicators to track South Africa's climate change response, a narrative (or storyline) approach based on a broader systems approach has been adopted. Within the South African context, the narrative approach aims to capture multiple compounding and interwoven interactions in a way that is widely accessible and facilitates discussion and engagement. Alternative approaches that deploy more complex formal systems descriptions risk being difficult to understand as well as portraying a more definitive understanding of the relevant systems than can be justified by current knowledge.

It is never possible to capture every interaction in the system nor is it possible to completely represent the complexity of the system. Therefore, the balance between representing robust complexity and providing clarity is a challenge that brings with it limitations. The primary limitation of the narrative approach is in its subjectiveness. Each narrative could be approached using a number of possible entry points and consist of a range of elements that make up the narrative 'string'. In addition, system linkages may, in some cases, be context or region specific meaning that they cannot be applied equally throughout the South African system. This is particularly the case where differences between summer and winter rainfall regions occur. The risk introduced through making these 'subjective' choices has been partially mitigated by engaging experts in the construction of the narratives. However, the narratives are primarily meant to act as springboards for future iteration and refinement based on emergent needs. Hence this limitation is not insurmountable, and could be viewed as an advantage of the approach as it provides scope for future changes rather than presenting a static picture. Additionally, the principle of capturing diverse perspectives should be central to the ongoing development of the narratives.

Reflections on future narrative and indicator refinement
Each of the narratives has a comprehensive set of accompanying indicators that represent that narrative. Future iterations require further engagement around the indicator selection and combination. More specifically, it is recommended that:

- For the Climate Realities Narrative 0 the way forward will require close collaboration with SAWS, as well as with data custodians such as the ARC, in order to ensure the application of the best and most recent data as well as alignment with the statistical analysis and messaging of other national reporting. There is also scope to improve and expand the existing methodologies, for example adding statistical significance to the analyses and expanding the wind anomalies Indicator 0.5 to include speed and direction at different times of the year.
- Narrative 1 on Economic Structure, Work Creation and Economic Growth requires various data going forward. Much of the required data currently does not exist, or is not reported on in a way that enables consolidation of data across institutions (e.g. Eskom jobs against REIPPPP jobs). For this narrative the way forward thus requires broader mobilisation and discussions that can enable the collection and alignment of various data, such as the reporting of GHGs under the same categories as trade data to show GHG emissions per key export commodity and female employment data, in job years, reported by specific electricity sub-sectors (coal, nuclear, gas, wind, solar, landfill gas).
- Narrative 2 on The Energy Transition has similar requirements as Narrative 1 in terms of the way

forward. Since the energy transition raises key policy questions which may not have been addressed before, a number of indicators for which no data is currently available would also be useful to track the changes in the energy system and associated relevant social, economic and environmental indicators. Hence the way forward for Narrative 2 requires broader mobilisation and discussions to enable the collection and alignment of various data.

- Narrative 3 Water and Climate Change requires data and elaboration, as well as input by various stakeholders going forward. This includes detailed discussions with water quality experts, as well as collaboration with Statistics South Africa on the indicators on equity and access. This narrative set out to bring water and climate change issues closer to the broader national development goals, but in so doing it has moved away from the environmental linkages. Future iterations of this narrative and its indicators may therefore require the inclusion of indicators that address ecological reserves and ecological infrastructure.
- Within the Social Vulnerability Narrative 4 indicators drawing in related elements of social vulnerability such as health and education can be added such as the climate proofing of health facilities and the climate sensitivity of housing structures which links to health impacts. In addition aspects relating to communication and disaster risk management such as widespread affordable internet access could also be included as a means of reducing climate risk. Indicators could be added that grapple more deeply with the 'softer' aspects relating to climate change sensitivity and adaptive capacity.
- For Narrative 5 on Sustainable Urban Centres the way forward requires engagement with urban actors from a variety of backgrounds, including urban ecologists, spatial planners and social justice activists. It also requires working with Statistics South Africa to align analysis and ensure that the most appropriate datasets are applied, and with the National Disaster Management Centre (NDMC) for application of the best and most appropriate local datasets. The expansion of focus, to include secondary cities in addition to the eight metros, should also be discussed going forward – with data availability and complexity of analysis in mind.
- Narrative 6 on Sustainable Rural and Semi-Rural Landscapes requires substantial work to create a more complete picture. Additional indicators need to be weaved in, such as indicators relating to land tenure, land redistribution, employment, economic opportunity and service delivery. There is also a need to establish a clear definition of rural and semi-rural areas, and to spatially align the indicators so that they each represent the same geographic area.

A number of discussions have taken place during the course of the narrative and indicator development within UCT, with external experts, and between UCT, DFFE and GIZ. This has led to reflections and recommendations worth considering for future iterations of this report and its indicators:

- The addition of anecdotal cases to reflect the diversity within trends;
- For each indicator make explicit linkages to national targets where possible and relevant;
- For each indicator make explicit what the desired trend is;
- Explicitly address the issue of food security and climate change, which is a gap across the current narratives;
- Critically reflect on the feasibility of long-term reporting for each of the proposed indicators;
- Link to the State of the Environment (SoE) reporting indicators and other relevant national datasets;
- Discuss whether keeping the narratives but detaching the indicators could be a better approach for future iterations.

DATA CHALLENGES

Climate change and its associated challenges pose a wide range of new policy challenges, which require either new datasets or more detailed data than is currently publicly available. In some instances, new data sources have been developed and institutionalised (for instance the GHG inventory and the associated reporting regulations), but there are still very significant data challenges. Locating and accessing data is a challenge, and once that is resolved there is often a lack of alignment between the datasets that are available. For example, the difference in reporting styles of Eskom and REIPPPP employment numbers makes tracking and comparison very difficult, with Eskom reporting data on a different annual calendar (based on the financial year) than other entities.

Bringing together the social, environmental and economic aspects of climate change poses an additional challenge, as data across these spheres tends to be different in format, style, time frame and scale. With regards to spatial scale the Rural and Semi-Rural Landscapes Narrative 6 proved particularly challenging, and the spatial disaggregation of various datasets (e.g. National Biodiversity Assessment reported biodiversity-employment and Statistics South Africa poverty trend data) along a single definition of rural and semi-rural landscapes was not possible. Dealing with these complex cross-sectoral challenges will require processes to collect, verify and present data which is official, comparable and relevant to the multifaceted context of climate change.

KEY INSIGHTS FROM INDICATORS

Climate analysis provides a picture of increasing temperatures across South Africa with exponential increases in extreme events. As a whole, the country has shown a drying trend in the last decade with some strong regional drought events. There has also been a decrease in intense rainfall events.

Sea surface temperatures show complex patterns of warming and cooling and these patterns change significantly from year-to-year. Warming trends are evident in the northern part of the Eastern Cape and the KwaZulu-Natal coastal zone, and especially the Agulhas Current System area. However, this trend is over the relatively short (1981-2019) period and could be related to longer-term decadal variability.

In climate change mitigation efforts, South Africa's overall emissions have remained relatively stable since 2010, and in terms of its international emissions targets, its emissions are currently far lower than anticipated in previous studies. Per capita emissions are around 40% above the world average, on a par with lower-carbon developed economies and major developing economies such as China, but above most developing economies. These have declined slightly since 2010 – even though the population has grown. Energy-related emissions constitute the majority of South Africa's emissions (around 80% since 2000) but have declined slightly since 2010. Of these, energy industries constitute the majority (67% of energy emissions in 2015), primarily from electricity and liquid fuels production, followed by transport (13%) and industry (8%). The intensity of GHG emissions per unit of primary energy showed a very slight decline from 2000 to 2015, however a more marked decline should result from the increased investment in renewable energy contemplated in IRP2019. The drop in intensity is partly driven by lower economic growth rates, but also by a structural change in the economy – evidenced by a decline in emissions intensity of the industrial sector (excluding energy). The technology mix which produces South Africa's electricity is still dominated by coal power. The decline in output since 2010 is largely a decline in coal-fired generation.

Emissions in the transport sector, primarily from road transport and dominated by liquid fuels, have grown steadily from 2000 to 2015, however per capita transport emissions have stabilised since 2008. This can be expected to change with the anticipated electrification of transport in the 2020s, however there is extremely low market penetration of electric vehicles so far in South Africa. There is an increasing trend in GHG emissions from local, as opposed to international, aviation and the rate of car ownership is indicative of a growing middle class who increasingly travel by air and drive private vehicles.

From 1994 to 2015 electrification levels amongst households in South Africa increased dramatically from 35% to 85,5%. However, this trend has stalled since 2015 and the household energy mix has seen an increase in the use of alternative sources for lighting.

The renewable energy sector is already making up for the shortfall in coal-fired electricity jobs resulting from the shift away from coal. While the data are not yet perfectly commensurate, there appears to be considerable employment creation in the construction and operating of renewable energy plants. South Africa has made modest progress in terms of increasing the number of people employed per unit of GHG emissions and in 'carbon productivity' – the GDP that is produced per unit of GHG emissions. In both instances, however, South Africa performs significantly worse than the global average, and the rate of decarbonisation of GDP over the past three decades has been slower than the global rate.

South Africa is a water-scarce country where water supply, which is central to the economy, is rapidly approaching full utilisation, and where a great proportion of the population still do not have equitable access to sustainable water or sanitation provision. Although there are many factors that influence access to potable water, the observed prolonged drought experienced over the past five years may have negatively influenced overall access to potable water. In the context of a changing climate and other pressures influencing water availability, water scarcity will potentially increase in the future. Therefore, it is important that water is conserved and the water supplies are diversified where possible.

There is a strong interrelationship between social vulnerability and equitable access to potable water and sanitation services.

Other health impacts associated with climate change include elevated mortality risk due to extreme temperatures, particularly amongst the very young and the elderly. Similarly pregnant women and children under five are the most vulnerable groups affected by malaria, a vector- borne disease with a strong correlation to climate. Although the population at risk has expanded over the reporting period, this is also influenced by the timing of preventive measures and subsequent timing of conditions favourable for the expansion of the disease vector. Proactive integrated monitoring across both climate and preventive indicators is therefore key to effectively managing this risk.

Consistent with trends on the continent and beyond, all eight South African metropolitan municipalities show considerable population growth and increasing urban density. In parallel, informal dwellings show an encouraging decreasing trend, with the exception of the City of Cape Town where there was a slight increase between 2001 and 2011. Growing population rates alongside increasing density and decreasing informality can be seen as positive, if assuming that increasing urban density means that cities are becoming more compact and efficient – spaces where high density enables efficient service delivery and transport mechanisms – and if it means that people have decent housing in areas with low hazard risk and proximity to economic activity. The public sector is commonly a large employer in the metros with a significant spatial footprint and presence. Energy and water efficiency, if prioritised at this level, would have a positive impact on the metros' energy and water demand as well as providing leadership to the residents. The case study included which showcases the City of Cape Town's decreased electricity consumption on its own buildings therefore provides an encouraging example. However, the change exhibited in this case study is slight and isolated to one parameter and one metro. This needs to be rolled out to all metros and include other parameters that comprise a more integrated climate smart approach.

The Cape Town ecosystem services case study indicates that urban ecosystems are functioning at levels significantly below their potential, yet tracking through time and for other cities, is required to see whether this is the case nationally. The urban drought indicator showed that all eight metros experiencing moderate to severe drought conditions over four years. Seen together with the drought conditions reported on in the Water and Climate Change Narrative, as well as the temperature and rainfall trends reported on in Narrative 0, there is clearly a need to monitor these trends closely. Despite a declining number of floods, the damage from flooding events reported in the metros is increasing. This may point to other drivers of damage such as high levels of physical and social vulnerability and exposure concentrated in the dense urban areas. This needs to be further explored.

The widespread and intense drought reported on in the Water and Development Narrative, is not reflected in the wheat and maize yields reported on here. Despite large portions of South Africa's maize production being rainfed rather than irrigated, yields have steadily increased. Here improvements in farming practices and techniques have potentially played a role, compensating for the impacts of drought. The longer term trajectory of yields could be monitored and reflected upon in future in the context of other factors such as market fluctuations and farming practices.

Finally, fires play an important role in the habitat vitality and renewal of South African ecosystems. Observations are indicating an overall decrease in the extent of burned areas over the last five years. This is interesting in the context of the increased frequency of drought conditions, and points to the complex interconnections between fuel load, meteorological conditions, fire management practices and land use changes.

NEXT STEPS – PROCESS RECOMMENDATIONS

This set of narratives and associated indicators provides a basis for discussion around the systemic nature of the climate change challenge and our national response to this challenge. It can also provide the catalyst for in-depth disciplinary discussions with sectoral experts across South Africa and internationally, for example, water quality experts, health experts etc. These further discussions should be seen as a key advantage of taking a systemic and narrative approach to the indicator development as they provide an entry point for co-development and representation of perspectives from a wide range of actors, including relevant government officials, practitioners and scientists.

The indicators also provide the basis from which to motivate for data collection to monitor key aspects of climate change within the South African context. Many of these aspects are not currently being monitored (for example, indicators related to urban transport, or ocean acidification) or are only being monitored at a national level, while regional or local specificity would provide a more appropriate level for tracking some of South Africa's climate change responses.

To best leverage current and future data collection, data management – including quality control, data provenance, long-term archiving as well as open access, should form a key activity moving forward. This should take place within a suitably capacitated and mandated institution to ensure cooperation and longevity.

In subsequent years, it is recommended that ongoing discussions with sectoral and disciplinary experts are used to continue to add to the indicator set, amend the existing indicators and update the narrative text and analysis in line with emerging reporting needs. Going forward, a co- development process will ensure that the indicators remain relevant and salient to the South African context. It is recommended that this co-development process be formalised as a semi-permanent collaborative working group facilitated by a suitable institution but drawing on the diversity of expertise across academia, the private sector and government.

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