forestry, fisheries & the environment

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

A.1 SOUTH AFRICA'S FOURTH NATIONAL COMMUNICATION PROJECT TEAM

DRAFTING OF CHAPTERS

Zutari Africa:	Chapter 1, National Circumstances
The Greenhouse:	Chapter 2, National Greenhouse Gas Inventory
The Greenhouse:	Chapter 3: South Africa's Measures Undertaken to Mitigate Climate Change
Zutari Africa:	Chapter 4: Other Information Considered Relevant to the Achievement of the Objective of the Convention
Zutari Africa:	Chapter 5: Constraints, Gaps, and Related Financial, Technical and Capacity Needs

This National Communication of South Africa has been prepared to comply with Articles 4 and 12 of the United Nations Framework Convention on Climate Change UNFCCC. Furthermore, it was prepared in alignment with the guidelines of the UNFCCC as per decision 17/CP.8 and its Annex. As per decision 1/CP.24, paragraph 43 (a), this edition of South Africa's National Communication (NC4) does not include the chapter on adaptation and the chapter will be reported in South Africa's inaugural Biennial Transparency Report[1]. This decision is informed by South Africa's commitment to provide a detailed and focused analysis of adaptation measures which will enhance the quality of reporting and specificity of strategies in response to climate change, in accordance with international expectations and our national circumstances.

CHAPTERS' INTERNAL REVIEW

Department of Forestry, Fisheries and the Environment

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[1] United Nations Framework Convention on Climate Change. (2018). FCCC/PA/CMA/2018/3/Add.2. Decision 18/CMA.1, Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement Annex, paragraph 104 to 117. UNFCCC.

CHAPTERS' INTEGRATION AND INDEPENDENT REVIEW

Promethium Carbon

PROJECT MANAGEMENT

Department of Forestry, Fisheries and the Environment

Sandra Motshwanedi (Project Manager)

Abbreviations and Acronyms

AAMP	Agriculture and Agro-Processing Masterplan
ACCESS	Applied Centre for Climate and Earth Systems Sciences
ACMI	Africa Carbon Markets Initiative
ACMP	Association of Cementitious Material Producers
AFOLU	Agriculture, Forestry and Other Land Use
APAP	Agricultural Policy Action Plan
ARC	Agricultural Research Council
AU	African Union
BAU	Business As Usual
BGIS	Biodiversity Geographical Information Systems
BIS	Biofuels Industrial Strategy
BTR	Biennial Transparency Report
BUR	Biennial Update Report
CA	Conservation Agriculture
CARA	Conservation of Agricultural Resources Act
CBO	Community-Based Organisation
CCGT	Combined-Cycle Gas Turbine
CCS	Carbon Capture Storage
CCUS	Carbon Capture, Utilisation and Storage
CDM	Clean Development Mechanism
CE	Circular Economy
CER	Certified Emission Reduction
CF2	Cleaner Fuels II
CH4	Methane
CHP	Combined Heat and Power
CIP	Climate Information Portal
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO2	Carbon Dioxide
CO2e	Carbon Dioxide Equivalent
COAS	Carbon Offset Administration System
COGTA	Cooperative Governance and Traditional Affairs
COP	Conference of the Parties
CoPs	Communities of Practice
CP	Consortium Partners
CSAG	Climate System Analysis Group
CSIR	Council for Scientific and Industrial Research
CSIS	Climate Services Information System
CTCN	Climate Technology Centre and Network

DAEA	Department of Agriculture and Environmental Affairs
DAFF	Department of Agriculture, Forestry and Fisheries
DBSA	Development Bank of Southern Africa
DEA	Department of Environmental Affairs
DEAT	Department of Environmental Affairs and Tourism
DEFF	Department of Environment, Forestry and Fisheries
DERO	Desired Emission Reduction Outcomes
DFFE	Department of Forestry, Fisheries and the Environment
DMRE	Department of Mineral Resources and Energy
DNA	Designated National Authority
DoA	Department of Agriculture
DoE	Department of Energy
DOH	Department of Health
DOM	Dead Organic Matter
DoT	Department of Transport
DPE	Department of Public Enterprises
DRI	Direct Reduced Iron
DRR	Disaster Risk Reduction
DSI	Department of Science and Innovation
DST	Department of Science and Technology
DTI	Department of Trade and Industry
DTIC	Department of Trade, Industry and Competition
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EAF	Electric Arc Furnace
EEDSM	Energy Efficiency Demand Side Management
EF	Emissions Factor
ERC	Energy Research Centre
EU	European Union
FAO	Food and Agriculture Organization
FOLU	Forestry and Other Land Use
FSC	Forestry Stewardship Council
GDARD	Gauteng Department of Agriculture and Rural Development
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GEOSS	Global Earth Observation System of Systems
GFCS	Global Framework for Climate Services
GgCO2e	Gigagram Carbon Dioxide Equivalent
GHG	Greenhouse Gas
GHGIP	Greenhouse Gas Improvement Programme
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit

GS	Gold Standard
GTS	Green Transport Strategy
GW	Gigawatt
GWP	Global Warming Potential
ha	Hectare
HFC	Hydrofluorocarbon
HSRM	Hydrogen Society Roadmap
HWP	Harvested Wood Products
HySA	Hydrogen South Africa Programme
ICT	Information and communication technology
IEP	Integrated Energy Plan
IGCCC	Intergovernmental Committee on Climate Change
IPAP	Industrial Policy and Action Plan
IPBES	International Platform for Biodiversity and Environmental Services
IPCC	Intergovernmental Panel on Climate Change
IPCC SAR	Intergovernmental Panel on Climate Change Second Assessment Report
IPP	Independent Power Producers
IPPU	Industrial Processes and Product Use
IRCTT	Informal REDD+ Consultative Task Team
IRP	Integrated Resource Plan
IUCN	International Union for the Conservation of Nature
JET	Just Energy Transition
JET-IP	Just Energy Transition Investment Plan
KCA	Key Category Analysis
ktCO2eq	Kilotonne Carbon Dioxide Equivalent
kVA	Kilovolt Ampere
kWh	Kilowatt-hours
LED	Low Emitting Diode
LEDS	Low Emissions Development Strategy
LFG	Landfill Gas
LNG	Liquified Natural Gas
LTAS	Long-Term Adaptation Strategy
LTMS	Long-Term Mitigation Scenarios
LULUCF	Land Use, Land Use Change and Forestry
M&E	Monitoring and Evaluation
MACC	Marginal Abatement Cost Curve
MCA	Multi-Criteria Assessment
MCF	Methane Conversion Factor
MEPS	Minimum Energy Performance Standards
MODIS	Moderate Resolution Imaging Spectroradiometer
MOU	Memorandum of Understanding

MPA	Mitigation Potential Analysis
MPRDA	Mineral and Petroleum Resources Development Act
MRV	Measurement, Reporting, and Verification
MtCO2e	Metric Tonne Carbon Dioxide Equivalent
MTSF	Medium-Term Strategic Framework
MW	Megawatt
N2O	Nitrous Oxide
NAAMSA	National Association of Automobile Manufacturers of South Africa
NAEIS	National Emissions Inventory System
NAMA	Nationally Appropriate Mitigation Action
NBI	National Business Initiative
NC	National Communications
NCCC	National Committee on Climate Change
NCCIS	National Climate Change Information System
NCCRD	National Climate Change Response Database
NCCRP	National Climate Change Response Policy
NCV	Net Calorific Value
NDA	National Designated Authority
NDC	Nationally Determined Contribution
NDHSP	National Department of Health and Strategic Plan
NDP	National Development Plan
NEES	National Energy Efficiency Strategy
NEMA	National Environmental Management Act
NERSA	National Energy Regulator of South Africa
NEV	New Energy Vehicle
NF3	Nitrogen Trifluoride
NFCS	National Framework for Climate Services
NGER	National Greenhouse Gas Emissions Reporting Regulations
NGHGIP	National Greenhouse Gas Inventory Programme
NGHGIS	National Greenhouse Gas Inventory System
NGO	Non-Governmental Organisation
NIE	National Implementing Entity
NIP	National Infrastructure Plan
NIPF	National Industrial Policy Framework
NLC	National Land Cover
NMT	Non-Motorized Transport
NMVOC	Non-Methane Volatile Organic Compounds
NOx	Nitrogen Oxides
NRF	National Research Foundation
NT	National Treasury
NTCSA	National Terrestrial Carbon Sink Assessment

NWMS	National Waste Management Strategy
OPUC	Other Process Use of Carbonates
PAMs	Policies and Measures
PCC	Presidential Climate Commission
PFC	Perfluorocarbon
PPP	Public Private Partnership
PV	Photovoltaic
QA	Quality Assurance
QC	Quality Control
QGIS	Quantum Geographic Information System
R&D	Research and Development
RDI	Research, Development and Innovation
REC	Renewable Energy Certificate
RECP	Resource Efficient and Cleaner Production
RECSA	Renewable Energy Certificate South Africa
REDD+	Reducing Emissions from Deforestation and Forest Degradation
REDISA	Recycling and Economic Development Initiative of South Africa
REFIT	Renewable Energy Feed-in Tariff
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
RMIPPPP	Risk Mitigation Independent Power Producers Procurement Programme
RSA	Republic of South Africa
S&L	Standards and Labelling
S@S	Separation at Source
SABS	South African Bureau of Standards
SACCCS	South African Centre for Carbon Capture and Storage
SADC	Southern African Development Community
SAEON	South African Environmental Observation Network
SAGERS	South African Greenhouse Gas Emissions Reporting System
SALA	Subdivision of Agricultural Land Act
SA-LEDS	South African Low Emissions Development Strategy
SALGA	South African Local Government Association
SAM	Social accounting Matrix
SANBI	South African National Biodiversity Institute
SANEDI	South African National Energy Development Institute
SANLC	South African National Land Cover
SAPIA	South African Petroleum Industry Association
SAR	Second Assessment Report
SAREM	South African Renewable Energy Masterplan
SAWS	South African Weather Service
SET	Sectoral Emission Target
SF6	Sulphur Hexafluoride

SJRPs	Sector Jobs Resilience Plans
SNC	Second National Communication
SOE	Sate-Owned Enterprises
SOx	Sulphur Oxides
SPLUMA	Spatial Planning and Land Use Management Act
SSEG	Small-Scale Embedded Generation
TBC	To be Confirmed
TNC	Third National Communication
TVET	Technical Vocational Education and Training
TWh	Terrawatt-hours
UCT	University of Cape Town
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
UPRD	Upstream Petroleum Resources Development
USAID	United States Agency for International Development
VCM	Voluntary Carbon Market
VCS	Verified Carbon Standard
WAM	With Additional Measures
WEM	With Existing Measures
WMO	World Meteorological Organization
WOM	Without Measures
WRI	World Resources Institute
WWF	Worldwide Fund for Nature
ZAR	South African Rand

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Executive Summary

South Africa develops National Communications in accordance with Articles 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC). The initial National Communication was submitted to the UNFCCC in 2004, followed by the second National communication in 2011 and Third National Communication in 2018. This document constitutes South Africa’s Fourth National Communication.

National circumstances

Chapter 1 offers a comprehensive update to South Africa's geographical, climatic, environmental, political, and socio-economic landscape, with an emphasis on its vulnerability to climate change and climate variability. The chapter also explains the planning and reporting documents produced at the national level for international reporting purposes, which inform national and regional priorities for addressing climate change within the context of national development programs, plans, and strategies. Lastly, the chapter outlines South Africa's institutional arrangements for preparing National Communications and implementing measures to meet the Convention's objectives.

South Africa is located at the Southern tip of Africa and is bordered by the Atlantic Ocean to the west and the Indian Ocean to the south and east. Its neighbouring countries are Namibia, Botswana, Zimbabwe, Mozambique, eSwatini and Lesotho. South Africa's land surface spans latitudes 22°S to 35°S and longitudes 17°E to 33°E, covering a total area of 1 220 813 square kilometres. . The Marion and Prince Edward islands are also nearby, at a distance of 1 920 km southeast of Cape Town, having been seized by the South African government in 1947. Additionally, there are two ocean currents around South Africa's coastlines: the cold Benguela Current flows north along the western coast as far as southern Angola, while the warm Mozambique-Agulhas Current skirts the eastern and southern coasts as far as Cape Agulhas.

South Africa is in a subtropical climate and benefits from a temperate temperature due to the inner plateau's altitude and the ocean's influence on three of its four sides. The country is dry as it receives approximately 500 millimetres of rain on average each year. Except for the South-Western Cape, the majority of South Africa is in the summer rainfall zone, with the rainy season running from November to March and the dry season from May to September (Grab and Knight, 2015). Typically, summers tend to be humid and warm in the East Coast, while the West and North experience dry conditions with extremely hot conditions in the West and North. Most tropical-temperate troughs and easterly tropical air flow over the interior are linked to summer rains.

The temperatures in South Africa have been moderately warm compared to years before which can be attributed to the country's overall high rainfall levels (South African Weather Services (SAWS), 2021). Based on the data from 26 climate stations, the annual mean temperature anomalies for 2021 were, on average, marginally higher than the reference period (1981–2010), making it roughly the 13th hottest year on record since 1951. The country is shown to be warming by 0.160°C every decade, which is statistically significant at the 5% level. Additionally, the rainfall in 2021 was notable as it was far above average throughout a large portion of South Africa. In the summer of 2021–2022, El Niño-Southern Oscillation (ENSO) was in a La Nina phase, which is characterised by rainfall that is above average in most of the summer rainfall zones.

The projected mid-year population in 2022 was 60.6 million with 31.0 million people (approximately 51.1% of the population), being female (StatsSA, 2022). Approximately 81% of all South Africans are black Africans, who make up the majority (49.1 million) of the country's population. Additionally, 4.6 million people identify as white, 5.3 million as coloured, and 1.5 million as Indian or Asian. With over 16.1 million inhabitants (26.6% of the total population of South Africa), Gauteng continues to have the highest population proportion. With an estimated 11.54 million residents (19.0%), KwaZulu-Natal is the province with the second-largest population and the Northern Cape continues to have the smallest percentage of South Africa's population, with a population of roughly 1.31 million (2.2%).

National Greenhouse Gas Inventory

This chapter presents a summary of South Africa's 8th National Greenhouse Gas (GHG) Inventory, covering the period 2000 to 2020. The inventory was compiled in accordance with the 2006 IPCC Guidelines for National GHG Inventories, the Revised Supplementary Methods and Good Practice Guidance arising from the Kyoto Protocol, and the 2019 Refinement to the 2006 IPCC Guidelines (IPCC, 2006, 2014, 2019). The national inventory includes both sources of GHG emissions and removals by sinks covering four sectors: Energy; Industrial Process and Product Use (IPPU); Agriculture, Forestry and Other Land Use (AFOLU); and Waste.

South Africa's GHG emissions for 2020 totalled 468 812 $GgCO_2e$, excluding emissions from forestry and other land use (FOLU). The contribution of emissions from FOLU results in net emissions of 442 125 $GgCO_2e$. The energy sector accounted for 86% of total emissions (including FOLU) in 2020, an increase from 83% in 2000. Overall, the energy sector showed a 2.2% increase in emissions from 2000 to 2020. GHG emissions from the IPPU and AFOLU (including FOLU) decreased by 23% and 40% from 2000 to 2020 respectively.

The waste sector saw an increase in emissions of 26% from 2000 to 2020. Overall, net GHG emissions in South Africa have decreased by 0.84% since 2000, from 445 885 $GgCO_2e$ to 442 125 $GgCO_2e$. GHG emissions (including FOLU) rose steadily reaching a peak in 2009 (552 758 $GgCO_2e$), before decreasing from 2009 to 2020. This can be attributed to several factors including a deteriorating economy, coupled with the impact of COVID-19.

The energy sector contributed 81% of the total gross GHG inventory (excluding FOLU emission) in 2020, an increase from 79.9% in 2000. The AFOLU sector (excluding FOLU emissions) is the second largest contributor to emissions accounting for 9.1% of emissions in 2000, decreasing to 8.7% of the gross emissions in 2020. The IPPU has seen a decline in its contribution to total gross emissions from 7.1% in 2000 to 5.4% in 2020, particularly from 2015. The Waste sector has seen a steady increase in its contribution from 3.9% in 2000 to 4.9% in 2020. The inclusion of the FOLU component results in changes in the contribution from the Energy, IPPU, AFOLU and Waste sectors to 85.8%, 5.8%, 3.2% and 5.2% respectively **(**figure ESI below).

South Africa's net GHG emissions in 2020 were predominately CO_2 (82.3%), followed by CH_4 (13.4%) and N_2O (3.2%), with F-gas (HFC and PFC emissions) contributing 1.1%. The CO_2 emissions decreased by 2.6% from 2000 to 2020, with CH_4 and N_2O emissions increasing by 1.8% and 5.1% respectively during this period. F-gas saw a 414% increase from 2000 to 2020. HFC emissions from refrigeration were included from 2005 (contributing to a 74% increase from 2000 to 2005) and HFC emissions from the remainder of the Other Ozone Depleting Substances sub-sectors, excluding solvents, were included from 2011 (contributing to a 377% increase from 2000 to 2011). With respect to South Africa's gross GHG Inventory, CO_2 emissions decreased by 0.6% and CH_4 and N_2O emissions increased by 2.5% and 6.5%, respectively.

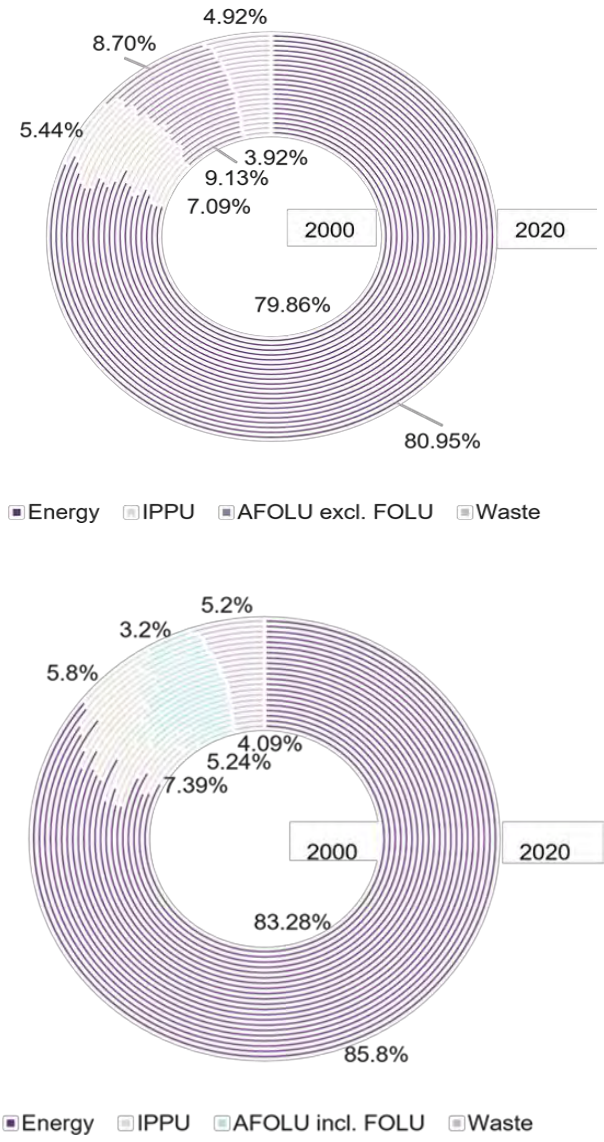

Figure ESI: Distribution of gross GHG emissions (top) and net GHG emissions (bottom) for South Africa (2000 to 2020), disaggregated by sector.

South Africa's Measures Undertaken to Mitigate Climate Change

This chapter outlines a range of cross-cutting policies and measures specifically designed to lower GHG emissions and facilitate sustainable development, aligning with the principles of a Just Transition and the broader challenge of climate change. This chapter also provides Monitoring and Evaluation (M&E) of Policies to reduce GHGs and the Progression of South Africa's M&E system. Climate Change Mitigation Barriers and Capacity Needs as well as South Africa's Projections to Mitigate Climate Change are outlined in the chapter.

By implementing policies and measures, South Africa aims to contribute to the global effort to mitigate climate change and build resilience. The policies and measures covered in this section include the overarching policies that affect the economy as a whole, namely the National Climate Change Bill and the Carbon Tax Act 2019, as well as sector-specific policies to reduce emissions. These sectors align with the IPCC sector delineation and include Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land Use (AFOLU), and Waste.

South Africa's updated Nationally Determined Contribution (NDC) of 2021 shows increased ambition compared to the first NDC submitted in 2015. The updated NDC target for 2025 provides for lower and upper emission trajectory ranges from 398 to 510 $MtCO_2eq$, decreasing to a range of 350 to 420 $MtCO_2eq$ in 2030. Considering South Africa's net emissions in 2020 totalled 442 $MtCO_2eq$, South Africa

is already in the range of the 2025 target, and only 22 $MtCO_2$ off the upper limit of the 2030 target. Net GHG emissions have decreased by almost 1% since 2000, peaking in 2009. This is largely attributed to a deteriorating economy coupled with the impact of COVID-19 and ongoing and prevalent load-shedding.

Other Information Considered Relevant to the Achievement of the Objective of the Convention

The purpose of this chapter is to provide information on Integrating Climate Change Considerations into Social, Economic and Environmental Policies and Actions. This chapter outlines the development and Transfer of Environmentally Sound Technologies (ESTs). Climate Change Research and Systematic Observation were provided in this chapter. The chapter presents Climate Change Education Training and Public Awareness as well as Capacity Building Needs. Several technical and capacity building needs and gaps were identified for the development of the National GHG Inventories. In this chapter gaps and needs are provided per type of support required.

Integrating climate change considerations into social, economic, and environmental policies and actions is a critical process for ensuring that climate change policies and national priorities are implemented concurrently, considering risks and opportunities while pursuing measures that are in tandem with the long-term development objectives of a country (OECD, 2009). Prioritising the pressing need to address climate change and its far-reaching impacts, South Africa has made significant progress in integrating climate change into its social, environmental, and economic policies. The country has adopted a proactive, comprehensive approach by establishing robust policies, measures, legal frameworks, and coordination mechanisms. Key economy-wide initiatives since 2017/18 have been outlined in detail in Chapter 1 of this report and include the National Environmental Management Action regulations on Pollution Prevention Plan (2017) and Greenhouse Gas Emissions reporting (2017), the Carbon Tax Act (2019), National Climate Change Adaptation Strategy (2020) and the Climate Change Bill (2022).

Constraints, Gaps, and Related Financial, Technical and Capacity Needs

In this chapter, information on constraints and gaps related to financial, technical, and capacity needs is provided. This includes the support needed and received to enable the preparation and submission of South Africa's fourth National Communication report. This chapter also outlines the additional needs and constraints for capacity building.

Significant and scaled-up resources are needed in South Africa for mitigation and adaptation actions across the entire economy. The South African government is putting in place an enabling institutional environment that can support a sustainable climate finance model, where mitigation and adaptation actions are funded over the long term and where this funding is accessible in a timeous manner to a broad range of stakeholders, but this will take time to complete.

1 National Circumstances

Climate change has become a living reality in South Africa as the impacts are experienced frequently, which can be seen from the extreme weather events the country has experienced, such as the Western Cape's wildfires and drought, with a prominent increase in vector- and waterborne diseases (Chersich and Wright, 2019). Furthermore, temperatures are predicted to rise by more than 4^0C in the southern African interior, with the central, western, and northern areas of South Africa predicted to rise by more than 6^0C. However, this is if there are no measures in place to reduce the country's Greenhouse Gas (GHG) emissions. Such environmental impacts disrupt the day-to-day living of South Africans, as, for instance, food security is reduced due to a loss of livestock and reduced crop yields, which also affects the economy as jobs are at risk with the increase in food prices due to scarcity. Therefore, climate change significantly affects South Africa's progress in achieving the Sustainable Development Goals (SDGs) and the National Development Goals, including the creation of jobs, poverty eradication, and fostering inclusive and equitable macroeconomic growth.

South Africa is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), which was signed in 1993 and ratified in 1997. All countries that ratify the Convention (the Parties) are required to address climate change, including monitoring trends in anthropogenic GHGs emissions. Therefore, as a Party to the Convention, the periodic reporting of a National Communication (NC) is required in accordance with the guidelines developed and adopted by the Conference of the Parties (COP). In addition, NCs also provide Parties with an opportunity to present information on national programmes, policies and plans, as well as using the information to develop projects that address climate change and facilitate adequate adaptation to climate change, either at the national or sectoral level. South Africa submitted its first, second and third NCs in 2003, 2011 and 2018 respectively.

This document serves as South Africa's fourth National Communication (NC4) which is an update of the information presented in the Third National Communication (TNC).

This first chapter, the National Circumstances, offers a comprehensive update on South Africa's geographical, climatic, environmental, political and socio-economic landscape, with an emphasis on its vulnerability to climate change and climate variability. The chapter also explains the planning and reporting documents produced at the national level for international reporting purposes. These documents inform national and regional priorities for addressing climate change within the context of national development programs, plans and strategies. Lastly, the chapter outlines South Africa's institutional arrangements for preparing NCs and implementing measures to meet the Convention's objectives.

In this chapter, South Africa's status quo, as set by decision 17/CP.8, paragraphs 3, 4 and 5 is provided, presenting an update on the following:

- National to Local Priorities
- Geography
- Environment
- Climate
- Population
- Economy
- Energy
- Infrastructure
- Water and Sanitation
- Agriculture, Forestry and Fisheries
- Institutional arrangements for Climate Change in the country

1.1 National, Provincial and Local Climate Change Priorities

South Africa has made significant strides in terms of advancing its climate change agenda, and this can be seen from the development of climate related policies, strategies and plans to establish new structures in climate change governance. In the sections below, a summary of climate change-related developments since the publication of the TNC is provided.

1.1.1 National Climate Change Priorities

South Africa's ten (10) national climate change priorities, as published in the 2011 National Climate Change White Paper and presented in the TNC, have not changed. What the Government has been doing is to advance and elaborate on those priorities through the publication of various legislation, policies, and plans, as well as the establishment of climate-related institutions. The government has been leading and coordinating efforts in various sectors and levels of government that go beyond what has traditionally been perceived as the terrain of 'environmental' governance. Figure 1-1 and Table 1-1 below present a timeline of some of the key national initiatives undertaken by the government to advance the country's climate change priorities:

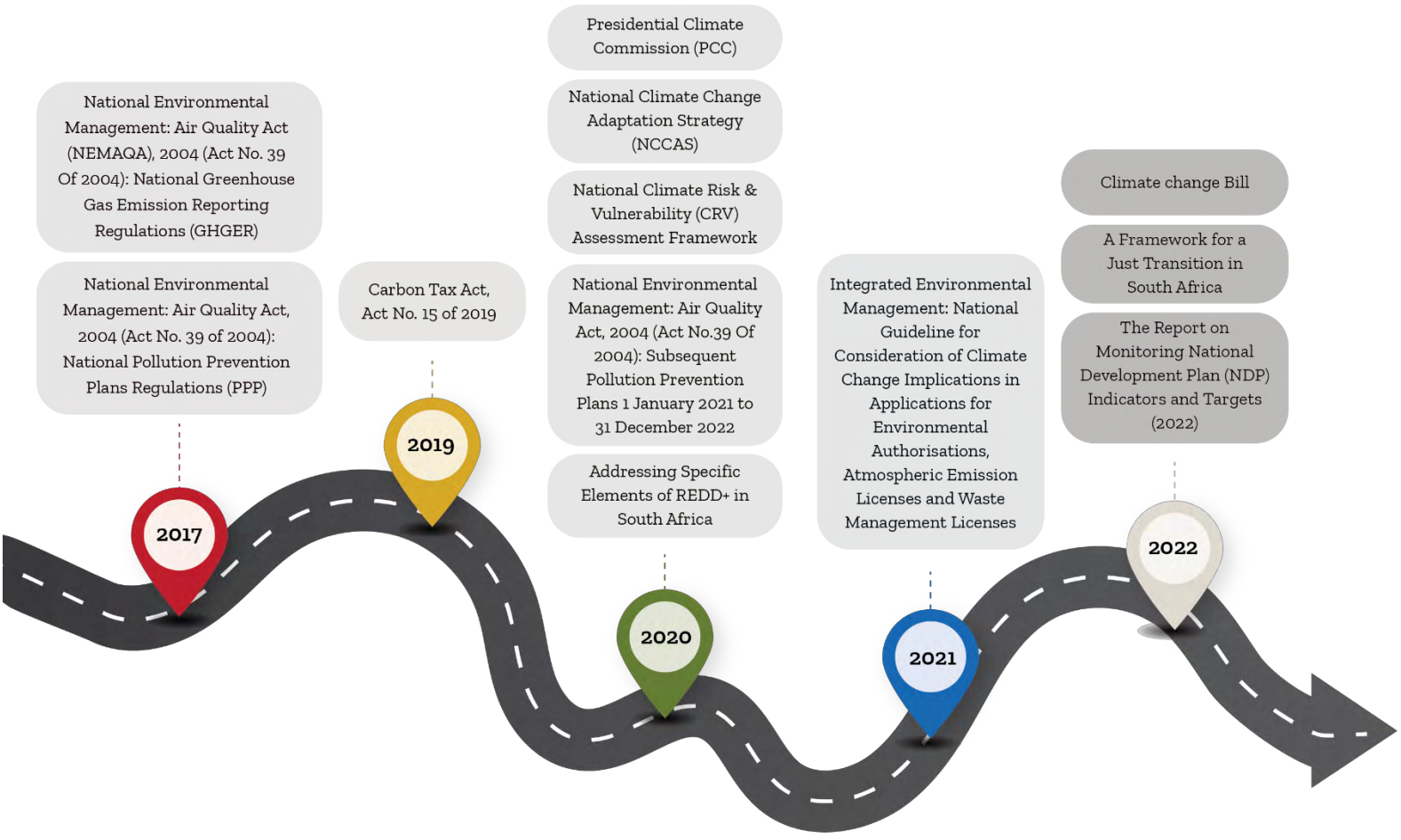

Figure 1-1: South Africa's key climate change response initiatives since publication of NC3 timeline

Table 1-1: South Africa's key climate change initiatives since the publication of NC3

Publication Year	Title
2017	• National Environmental Management: Air Quality Act (NEMAQA), 2004 (Act No. 39 Of 2004): National Greenhouse Gas Emission Reporting Regulations (GHGER)
	• National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004): National Pollution Prevention Plans Regulations (PPP)
2019	Carbon Tax Act, Act No. 15 of 2019
2020	• Presidential Climate Commission (PCC)
	• National Climate Change Adaptation Strategy (NCCAS)
	• National Climate Risk & Vulnerability (CRV) Assessment Framework
	• National Environmental Management: Air Quality Act, 2004 (Act No.39 Of 2004): Subsequent Pollution Prevention Plans 1 January 2021 to 31 December 2022
	• Addressing Specific Elements of REDD+ in South Africa
2021	Integrated Environmental Management: National Guideline for Consideration of Climate Change Implications in Applications for Environmental Authorisations, Atmospheric Emission Licenses and Waste Management Licenses
2022	Climate change Bill
	A Framework for a Just Transition in South Africa
	The Report on Monitoring National Development Plan (NDP) Indicators and Targets (2022)

1.1.1.1 National Greenhouse Gas Emission Reporting Regulations (2017)

Since 2017, the South African government has been focusing on legislating a climate change response. The National GHG emission Reporting Regulations was the first such piece of legislation that was promulgated in 2017, under the National Environmental Management: Air Quality Act (NEMAQA), 2004 (Act No. 39 of 2004). The purpose of these Regulations is to introduce a single national reporting system for the transparent reporting of GHG emissions, which is used to update and maintain a National Greenhouse Gas Inventory; to assist South Africa in meeting its reporting obligations under the UNFCCC and instrument treaties to which it is bound; and to inform the formulation and implementation of legislation and policy.

These regulations require registration of companies that own or operate facilities emitting GHGs that exceed a particular threshold. Additionally, these companies must then submit annual reports on the GHG emissions from those facilities.

1.1.1.2 National Pollution Prevention Plans Regulations

The National Pollution Prevention Plans Regulations is the second piece of legislation that was promulgated in 2017, still under NEMAQA. The purpose of these Regulations is to prescribe the requirements that pollution prevention plans for GHGs declared as priority air pollutants, need to comply with, in terms of section 29(3) of the Act. The Regulations require companies in priority sectors, particularly mining, electricity generation, minerals production, oil and gas, to prepare and submit plans on how they intend to reduce their GHG emissions, and then to submit annual progress reports on the implementation of such plans.

1.1.1.3 Carbon Tax Act, 2019: Act No. 15 of 2019

The third piece of legislation promulgated by government to support climate change response in South Africa is the Carbon Tax Act: Act No. 15 of 2019. The act serves as South Africa's tool for carbon pricing and provides for the imposition of a tax on GHGs emissions that exceed sector-specific thresholds. It focuses on GHG emissions from fuel combustion, fugitive emissions and emissions from certain industrial processes. In the first tax period of June 2019 – December 2019, the tax was set at ZAR120 per ton of CO_2e emissions and was determined to increase annually by a factor of Consumer Price Index (CPI) + 2% up to December 2022 and by a factor of CPI thereafter. By 2023 the carbon tax rate had increased to ZAR159 / tCO_2e emissions.

In the first phase of the carbon tax, which ends in 2025, various allowances have been permitted, in the form of tax-free allowances, allowances for carbon offsets, trade exposure allowances and tax benefits for the generation of electricity from renewable sources, all of which bring the effective carbon tax rate to between ZAR6 and ZAR48 per tCO_2e.

In his 2022 budget speech, Minister of Finance, Mr Enoch Godongwana announced that there will be significant increases in the carbon tax in the second phase from 2026 to 2030 to enhance the country's ability to achieve its ambitious NDC.

1.1.1.4 Presidential Climate Commission

In December 2020, President Cyril Ramaphosa established the Presidential Climate Commission (PCC) to oversee and facilitate a just transition to a low-emission and climate-resilient economy (Presidential Climate Commission, 2022). The PCC is a multi-stakeholder commission that advises the President on the country's climate change response and a just transition to a low-carbon climate-resilient economy and society. Its activities aim to address significant issues at the nexus of climate change and development, with a view to assisting South Africa's just and equitable transition to a sustainable economy (PCC, 2022).

The president of South Africa serves as the PCC's chair and is supported by a vice chair and 22 commissioners that represent a variety of perspectives. Ad hoc working groups across multiple theme areas meet more regularly than the commission itself, which meets once every three months. These working groups consists of representatives from government, industry, labour, civil society and university and research institutions.

In 2022, the Commission published South Africa's Framework for a Just Transition, which aims to bring coordination and coherence to just transition planning in South Africa (ibid). This Framework is presented in more detail in the section below.

1.1.1.5 A Framework for a Just Transition in South Africa

Published in 2022, the Just Transition Framework lays out a common vision for South Africa's just transition towards a low-carbon economy and climate resilience society. This Framework outlines comprehensive and clear details on the definition of a Just Transition for South Africa, guiding principles for the transition, at-risk sectors and value chains, key policy areas to give effect to the transition, effective governance arrangements and how the transition will be financed.

Government will use this Framework as a base to develop a cohesive national policy statement that will guide work on the Just Transition in the country. The Framework places human development issues at the forefront of decision-making, while concentrating on controlling the social and economic effects of those policies. The Framework also embodies the "leave no one behind", ensuring that such a transition really occurs in a just and inclusive manner.

It is envisaged that a detailed Just Transition implementation plan, based on this Framework, will be developed next, including timelines and budget allocation for the Just Transition.

1.1.1.6 National Climate Change Adaptation Strategy

Published in 2020, the National Climate Change Adaptation Strategy (NCCAS) sets out key areas for attaining the country's shared goal of climate resilience (DFFE, 2020). It focuses on adaptation to climate change, building upon principles in other South African laws and policies, such as the National Environmental Management Act (NEMA), and the Constitution, particularly Section 24, which addresses the right to a safe and healthy environment.

The NCCAS serves as a common point of reference for short- to medium-term climate change adaptation initiatives in South Africa, offering guidance to all governmental levels, sectors, and stakeholders that are impacted by climate variability and change. It also offers a tool for policymaking that allows the country's national goals for coping with climate change to be stated, giving all economic sectors broad direction. In addition, the NCCAS is intended to aid in the integration of crucial climate change adaptation priorities into development projects at various levels of government and business, which helps stakeholders allocate resources for climate change resilience. Furthermore, it promotes greater coherence and coordination of actions related to climate change adaptation among various institutions and governmental levels. Lastly, it supports South Africa in upholding its international obligations by outlining the nation's vulnerabilities, plans to mitigate those vulnerabilities and capitalise on opportunities, outlining the resources needed for such action, and demonstrating progress on climate change adaptation.

1.1.1.7 National Climate Risk & Vulnerability Assessment Framework

In parallel with the compilation of the NCCAS, the South African government developed and published the National Climate Risk and Vulnerability (CRV) Assessment Framework to identify the risks posed by climate change and to decide on the best course of action for adaptation (DEFF, 2020). Practitioners and decision-makers can determine the most vulnerable regions, sectors, and communities using the CRV Assessment Framework.

The CRV offers methods and resources for evaluating various aspects of climate change vulnerability. Additionally, it offers suggestions for creating an appropriate synthesis of various techniques and instruments for the evaluation of climate change vulnerability for government agencies, the corporate sector and other organisations.

1.1.1.8 National Environmental Management: Air Quality Act, 2004 (Act No.39 Of 2004): Subsequent Pollution Prevention Plans

This section provides details on the Submission of "Subsequent Pollution Prevention Plans" Under the National Environmental Management: Air Quality Act, 2004 (Act No. 39 Of 2004): National Pollution Prevention Plans Regulations as Published Under Government Notice No. R.712 in Government Gazette No. 40996 of 21 July 2017 and the Proposed Process to Manage Carbon Budgets for the Period 01 January 2021 to 31 December 2022. This submission was also developed to propose a process to manage the carbon budgets for the period of 01 January 2021 to 31 December 2022, as set out in the NEMAQA Schedule. These regulations were intended to act as an update to the section 29(3) of the Act, which specifies the standards that pollution prevention plans for GHGs labelled priority air pollutants must follow. The Department of Forestry Fisheries and Environment (DFFE) is in the process of developing the Climate Change Act (see Climate Change Bill below), which will legislate carbon budgets and mitigation plans (currently known as pollution prevention plans) and make provision for DFFE to publish regulations for Carbon Budgets and Mitigation Plans as soon as the proposed Act is promulgated. In addition, the DFFE also produced a method for allocating carbon budgets that would be used for the mandatory carbon budget system, which is expected to start on January 1, 2026, with the second phase of the carbon tax. The DFFE therefore encourages businesses to voluntarily use the period from 1 January 2021 to 31 December 2025 as a pilot period to test the linking of the carbon budgets and the mitigation plans, with the expectation that by the time the carbon budgets become required on 1 January 2026, they would already be utilising the new system. These regulations were to serve as an update to prescribe the requirements that pollution prevention plans of GHGs declared as priority air pollutants need to comply with in terms of section 29 (3) of the Act.

1.1.1.9 Addressing Specific Elements of Reduction of Emissions from Deforestation and Forest Degradation in South Africa

The establishment of the Informal Reduction of Emissions from Deforestation and Forest Degradation (REDD+) Consultative Task Team (IRCTT) in July 2015 marked the beginning of the National REDD+ Programme. The IRCTT, during the first meeting, suggested that South Africa adopt a more novel approach by having a Phase 0 (Readiness Phase) rather than the traditional stepwise approach (Phase 1-3) of REDD+ (as stated in UNFCCC Decision 1/CP.16, paragraph 73). The National Terrestrial Carbon Sinks Assessment first recognised REDD+ as one of the eight primary climate change mitigation options in the Agriculture, Forestry, and Other Land Use (AFOLU) sector. However, currently, it is a part of South Africa's Land-Based Mitigation Programme, which is also incorporated into the country's NDC under the Paris Agreement and the UNFCCC. The adoption of a national initiative to reduce emissions caused by deforestation and forest degradation (REDD+) has been singled out as a unique potential. In addition, various UNFCCC decisions, the current Paris Agreement (Article 5), the Katowice Paris Rulebook, and ultimately, South Africa's NDC supports the National REDD+ initiative in South Africa. The document entitled “Addressing Specific Elements of Reduction of Emissions from Deforestation and Forest Degradation in South Africa” is a result of a national stakeholder engagement conducted by the IRCTT, which was formed by the then-Departments of Agriculture, Forestry and Fisheries (DAFF) and Environmental Affairs (DEA). This engagement identified the need to develop several key elements to create an effective and efficient national programme.

The purpose of the document is to fully assess the South African Forest Scope and Definition for the development and implementation of REDD+, and to explore effective and efficient institutional arrangements for the REDD+ process for South Africa on a national level. Additional purposes of the documents are to assess the drivers of deforestation and forest degradation for three selected sites, to identify strategic prevention measures and associated costs which will serve as guidance for the development of the overall REDD+ strategy through specific examples.

1.1.1.10 Integrated Environmental Management: National Guideline for Consideration of Climate Change Implications in Applications for Environmental Authorisations, Atmospheric Emission Licenses and Waste Management Licenses.

When the Integrated Environmental Management: National Guideline for Consideration of Climate Change Implications in Applications for Environmental Authorisations (EA), the Atmospheric Emission Licences (AEL), and the Waste Management Licences (WML) were issued, it was a critical turning point for South Africa. These guidelines are intended to provide guidance on how to consider climate change impacts when conducting Environmental Impact Assessments (EIA) for applications for EAs, WMLs, and AELs. Additionally, the guideline includes details on its intended audience, the types of EIA processes and developments that apply to it, as well as what it will and will not do.

The guideline has sections on the generic principles for involving climate change specialists in EIA processes and the role of the Environmental Assessment Practitioner (EAP) in determining the need for a climate change specialist's input. With regards to the role and timing of a specialist study within the EIA process, regardless of whether the process begins prior to or during the submission of an application for statutory permission, specialists can be involved for various purposes throughout various phases of the EIA process if the need for a climate change specialist's contribution has been recognised by the EAP. In addition, roles and responsibilities of the various stakeholders involved with the EIA process as it pertains to climate change issues are included, ranging from the EAP, the climate change specialist, the applicant/proponent, and competent/licensing (decision-making) authorities. Furthermore, the document provides guidance on the extent and content of climate change assessments, the application of the impact mitigation measures, how to address direct, indirect and cumulative impacts. As most development take places around human settlements, the guideline addresses climate change adaptation and aims to ensure that the proposed development does not have detrimental impacts and exacerbates problems on the surrounding environment and other closely related infrastructure. Lastly, the document also contains information on the Environmental Management Programme (EMPr) requirements for impact management outcomes and impact management actions. The EMPr is crucial for any development that will likely have detrimental climate change impacts, and therefore, impact management outcomes and impact management actions regarding the mitigation measures for the climate change impacts are recorded in the EMPr.

1.1.1.11 Climate Change Bill

The Climate Change Bill, formally introduced in Parliament in February 2022, aims "*To enable the development of an effective climate change response and a long-term, just transition to a low-carbon and climate-resilient economy and society for South Africa in the context of sustainable development; and to provide for matters connected therewith*" (Parliament of Republic of South Africa, 2022). It provides guidance on an effective, progressive and incremental response to actual and expected climate change impacts (Climate Change Bill, 2022). The main objective of the Bill is to enable the development of an effective climate change response and the long-term, just transition to a climate-resilient and lower-carbon economy and society, and to provide for matters connected therewith. It outlines institutional arrangements for climate change response and provides for the implementation of various climate change responses, including the annual compilation of a national GHG inventory, the development of national adaptation strategies as well as the establishment of a mandatory carbon

budgeting system for high-emitting sectors. When promulgated into law, the Climate Change Act will be the foremost and overarching climate change legislation in the country.

1.1.1.12 Report On Monitoring National Development Plan (NDP) Indicators and Targets

With clearly stated catalytic priorities to achieve the National Development Plan (NDP) targets, the National Planning Commission (NPC) created an NDP Implementation Framework to guide implementation. The NPC has suggested that an NDP implementation tracker should be developed, expanded further, and used as an NDP implementation dashboard to track the advancement of chosen targets, goals, objectives and indicators. Since it is impossible to concentrate on every aspect, the tool records metrics that most accurately reflect some of the NDP's goals and objectives, whilst also taking data accessibility into account. The methodology of this analysis involves monitoring the development of the crucial NDP indicators.

The reduction of unemployment, poverty and inequality are one of the NDP's major aims. Building a capable and developing state, bringing stakeholders and social partners together in a social compact, strengthening human capabilities and social protection and strong leadership are all necessary for achieving these aims during the implementation phase of the plan. The NDP further states that enhanced interdepartmental cooperation across the three constitutional sectors of government -local, provincial and national - can help South Africa become an efficient and capable state. Furthermore, a comprehensive sociological approach is necessary for the NDP to be implemented successfully.

1.1.2 International Priorities

South Africa's international priorities to tackle climate change are reflected in the below-listed documents, which have been submitted to the UNFCCC:

- The first National Communication (NC1) (2004),
- South Africa's Climate Change Technology Needs Assessment (2007),
- Second National Communication (NC2) (2011),
- First Biennial Update Report (BUR1) (2014),
- Intended Nationally Determined Contribution (INDC) (2015),
- Second Biennial Update Report (BUR2) (2017),
- Third National Communication (TNC) (2018),
- Third Biennial Update Report (BUR3) (2019),
- Low Emissions Development Strategy (LEDS) (2020),
- Fourth Biennial Update Report (BUR4) (2021),
- South Africa's Nationally Determined Contribution (NDC) under the Paris Agreement (2021) (update).

1.1.2.1 South Africa's Biennial Update Reports (BURs) to the UNFCCC

The first, second and third BURs were submitted in 2014, 2017 and 2019 respectively. The first BUR reported on South Africa's Climate Change response for the years 2011 to 2014, while the second and third BURs contained information on South Africa's climate change response for the periods 2014 – 2017 and 2017 – 2019 respectively.

South Africa's BUR4 provides an update on the country's progress in developing and implementing its climate response policies, strategies and goals until 2021. It shows that South Africa reduced its

emissions significantly between 2000 and 2017, with overall emissions in 2017 almost 20% lower than in 2000. The development of renewable energy sources and increased energy efficiency have been the main factors contributing to this reduction. However, the industrial and transportation sectors produce significant amounts of GHG emissions and emissions from the Industrial Processes and Product Use (IPPU) sector are showing a modest upward trend, whereas those emissions from the Agriculture, Forestry, and other Land Use (AFOLU) sectors remain steady.

The report also emphasises the need for more funding and capacity-building to support the implementation and oversight of mitigation policies, as well as the need for additional measures to reduce emissions, such as the implementation of the Green Transport Strategy (GTS), which aims to reduce transport emissions. Finally, BUR4 highlights the fact that South Africa has been making significant progress towards becoming a low-carbon and climate-resilient society.

1.1.2.2 South Africa's Low Emission Development Strategy 2050 (SA-LEDS)

Submitted in 2020, South Africa's Low Emission Development Strategy 2050 (SA-LEDS) presents a vision of a South Africa that follows a low-carbon growth trajectory while making a fair contribution to the global effort to limit the average temperature increase, while ensuring a just transition and building the country's resilience to climate change (SA-LEDS, 2020). It focuses on mitigation measures that are currently being implemented by government to address climate change mitigation across the energy, industry, AFOLU and waste sectors, while also accounting for planned cross-sectoral measures that will contribute towards mitigation in the future. The SA-LEDS is viewed as a living document that assists in charting the country's path towards the goal of a net-zero carbon economy by 2050 (ibid).

1.1.2.3 South Africa's Nationally Determined Contribution (NDC) under the Paris Agreement

Prior to the 21st Conference of Parties to UNFCCC, South Africa submitted its Intended Nationally Determined Contribution (INDC) (RSA 2015) on September 25, 2015. On November 1, 2016, South Africa ratified the Paris Agreement, and the INDC became the country's first NDC (RSA, 2016). The first NDC was then updated and submitted in 2021.

The 2021 update, which reflects the country's highest degree of ambition, based on science and equity, considering the national conditions, builds on the 2015 submission. It contains amended mitigation targets that show significant progress as required by the Paris Agreement. The revised NDC aims to reduce carbon emissions to a trajectory range of 350 – 420 million tons of Carbon Dioxide equivalent (MtCo2e) by 2030, with a long-term vision to achieve net-zero by 2050, at the latest. The 2021 updated NDC also contains an updated adaptation NDC, which serves as the country's first adaptation communication pursuant to Article 7 of the Paris Agreement. The adaptation communication offers comprehensive details on South Africa's planned contribution to the global adaptation goal during the NDC period. It also outlines the anticipated climate impacts and provides a description of the recently approved NCCAS. Furthermore, it provides details of planned adaptation actions over the next several decades and their associated costs for key economic sectors that are likely to be most impacted by climate change.

1.1.3 Provincial Priorities

Since 2017, five out of nine South African provinces have updated their climate change strategies and action plans. These provinces are:

- Eastern Cape – The Draft Climate Change Adaptation Action Plan for the Eastern Cape (2017).
- Free State – The Revised Free State Climate Change Adaptation Strategy (2020/21).

- Gauteng – Gauteng City Region has an over-arching Climate Change Response Strategy and Action Plan (2020).
- Mpumalanga – Mpumalanga Climate Change Mitigation Strategy and Implementation Plan (2022),
- Western Cape – The Western Cape Climate Change Response strategy: 3rd Biennial Monitoring & Evaluation report (2019/20).

The other four provinces are in the process of updating their respective climate change strategies. The updated strategies will include considerations of both mitigation and adaptation measures. These four provinces are KwaZulu Natal, Limpopo, Northwest and the Northern Cape.

1.1.4 Local Priorities

As part of the efforts to combat climate change at local scales, the Council for Scientific and Industrial Research (CSIR) developed the Greenbook. The Greenbook is an online planning support tool that presents a range of adaption measures that local government can implement to improve climate-resilient development, as well as quantifiable scientific evidence on the possible impacts that climate change and urbanisation will have on the country's cities and towns (CSIR, 2019). It provides evidence of current and future (2050) climate risks and vulnerability for every local municipality in South Africa (including settlements) in the form of climate-change projections, multidimensional vulnerability indicators, population-growth projections, and climate hazard and impact modelling (Van Niekerk *et al.* 2020). It does this through the following action tools:

(a) **Story Maps** which present research results on the potential effects that a changing climate and an increase in urban population will have on South Africa's key resources and settlements.

(b) **Municipal Risk Profiles** providing climate risk information for every South African municipality from now to the year 2050. This information includes: vulnerability to climate change, population projections, exposure to climate hazards and the effects of climate change on key resources.

(c) **Adaptation Actions** which is a variety of planning and design options that can be incorporated into local decision-making to improve adaptation and reduce vulnerability.

(d) **Metroview** offers the current and future (2050) South African metropolitan cities' risk and vulnerability profiles.

(e) **Greenbook Training** provides training sessions that are designed to improve capacity across all levels of government (and beyond) for the purpose of proactively adapting South African settlements to the effects of hydro-meteorological hazards.

Since 2015, the following cities and metropolitan municipalities have developed Climate Change Action Plans and Strategies:

- Nelson Mandela Bay Metropolitan – Climate Change and Green Economy Action Plan (2015),
- Buffalo City Metropolitan Climate Change Strategy (2015),
- City of Ekurhuleni Metropolitan – Climate Change Response Strategy (2015), and Green City Action Plan (2022),
- Mangaung Metropolitan – Climate Change Adaptation and Mitigation Strategy (2017),
- eThekwini Metropolitan Municipality – Climate Action Plan (2019) and Climate Change Strategy (2022),

- City of Cape Town Metropolitan – Climate Change Action Plan (2021), and Climate Change Strategy (2021),
- City of Johannesburg Metropolitan - Climate Action Plan (2021),
- City of Tshwane Metropolitan – Climate Action Plan (2022).

1.2 Geography

With a coastline spanning more than 3 000 kilometres (km), South Africa occupies the southern tip of Africa, extending from Namibia's desert border on the Atlantic coast southward to the northern boundary of subtropical Mozambique on the Indian Ocean (GCIS, 2022). The land surface area of South Africa, which ranges from 22°S to 35°S latitudinally and from 17°E to 33°E longitudinally, is 1 220 813 km^2. The Marion and Prince Edward islands are also nearby, at a distance of 1 920 km southeast of Cape Town, having been seized by the South African government in 1947. Lesotho and Eswatini, two landlocked countries, as well as Mozambique, Zimbabwe, Botswana and Namibia are the six countries that share borders with South Africa.

Spectacular diverse relief features can be found throughout South Africa, including mountain peaks, forests, bushvelds, deserts and grasslands (GCIS, 2022). This is because the country has two physiographic surface areas, one of which is the interior plateau and the other being the territory between the plateau and the shore. The Great Escarpment, the most prominent and continuous relief feature, which divides the two regions, with a height above sea level ranging from around 1 500 metres (m) in the dolerite capped Roggeveld scarp in the southwest, to 3 482 m in the KwaZulu-Natal Drakensberg.

The inland plateau of the country is formed by the southern extension of the large African plateau, which extends all the way north to the Sahara Desert. The South African plateau is much lower, with an average height of only 1 200 metres above sea level and extensive plains, while the Lesotho Plateau is the highest, at more than 3 000 metres above sea level. The Great Escarpment and the shore are separated by a region that ranges in breadth from 80 km to 240 km in the east and south and from 60 km to 80 km in the west. It is acknowledged that the three primary subdivisions in that region are the eastern plateau slopes, the Cape folded belt and surrounding areas and the western plateau slopes.

Additionally, there are two ocean currents around South Africa's coastlines: the cold Benguela Current flows north along the western coast as far as southern Angola, while the warm Mozambique-Agulhas Current skirts in the eastern and southern coasts as far as Cape Agulhas. It is thought that the different temperatures between the two currents are what cause the varied climate and biodiversity (vegetation and marine life). The fishing sector in South Africa, which is centred on the west coast due to the cold sea that is substantially richer in oxygen, nitrates, phosphates and plankton than those on the east coast, is another example of this. Saldanha Bay on the west coast serves as the only ideal natural harbour.

1.3 Environment

At the southernmost tip of Africa, South Africa has a diversified and distinctive environment which varies from the lush coastal forests of KwaZulu-Natal to the arid landscapes of the Karoo. There are eight different biomes found in South Africa, as shown in the Figure 1-2 below:

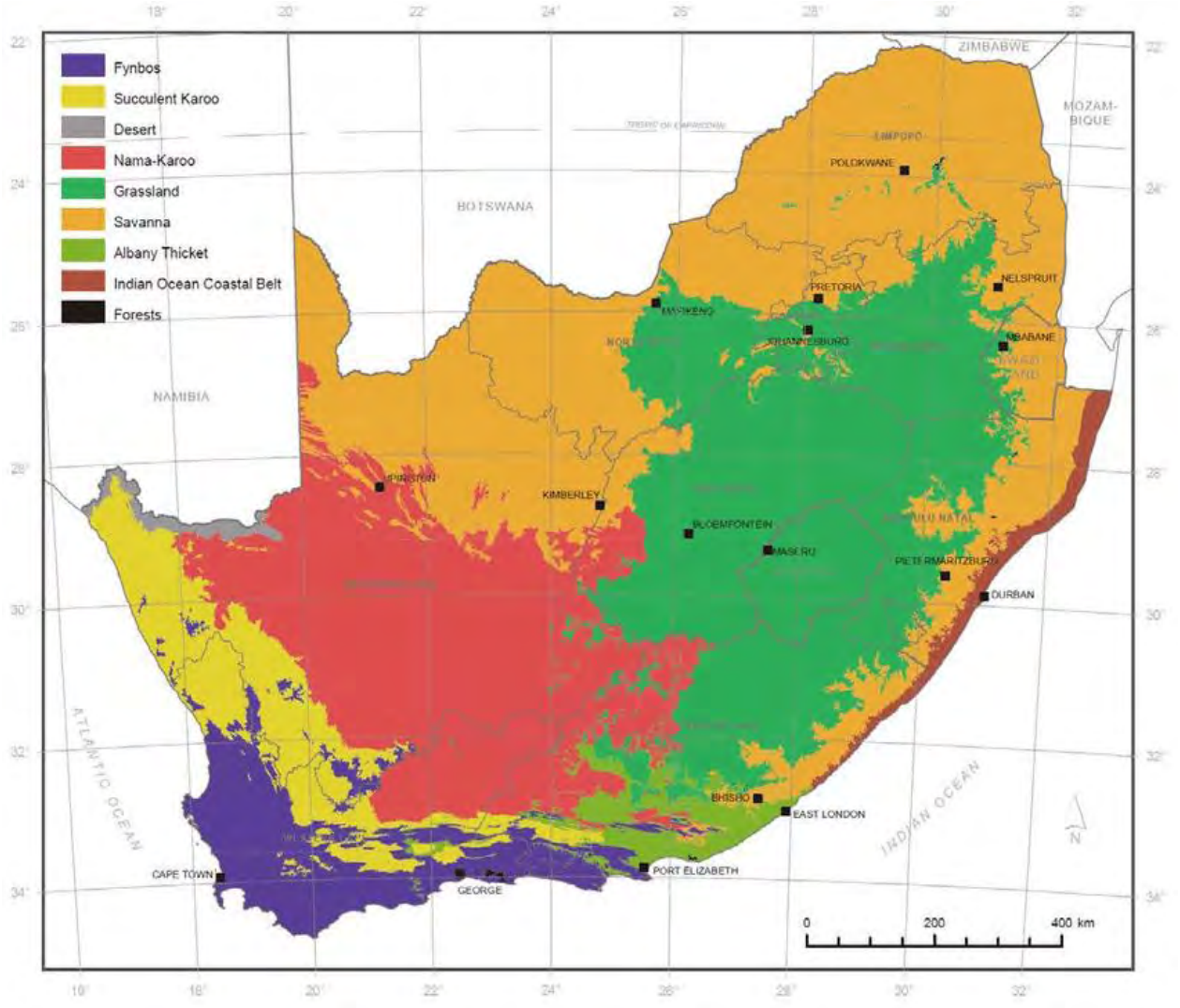

Figure 1-2: Biomes in South Africa

The 290 conservation parks in the country, which protect 300 mammal species, 860 bird species and 8 000 plant species, are located in these eight biomes. The annual sardine migration is one of the most well-known natural environmental events of its kind across the globe.

Artificial lakes used to irrigate crops predominate due to a lack of significant natural lakes in South Africa. The largest river in South Africa is the Orange River with its source being situated in the Drakensberg Mountains, traveling through the Lesotho Highlands and joining the Caledon River between the Eastern Cape and the Free State. The Orange River finally flows into the Atlantic Ocean, forming the Namibian border before it does so. Other significant rivers in the nation include the Vaal, Breede, Komati, Lepelle (formerly Olifants), Tugela, Umzimvubu, Limpopo and Molopo. Due to the year-round access difficulties caused by large sandbanks, most river mouths are unusable as harbours. Numerous species, many of which are only found in southern Africa, face an increased risk of becoming extinct due to anthropogenic climate change (Scholes and Engelbrecht, 2021). Approximately 17% of mammals, 15% of birds and 14% of plants in the country are currently thought to be in danger of going extinct because of environmental deterioration and loss of habitat. As a result of reduced water accessibility and more extreme weather, climate change has exacerbated these effects. Since habitats have been disrupted by human activity and anthropogenic climate change, it is more challenging for species to relocate to regions with suitable conditions.

According to the assessment of the state of the air in South Africa, ambient air concentrations of pollutants like sulphur dioxide (SO_2), particulate matter (PM10 and PM 2.5), Nitrogen dioxide (NO_2), nitrogen oxides (NOx), ozone (O_3), benzene (C_6H_6), and Volatile Organic Compounds (VOCs) continue to be of concern (DFFE, 2021). Pollutants released from a variety of sources have an impact on the quality of the air in different parts of South Africa. These sources include those that use fossil fuels to generate electricity, industrial processes, waste disposal, transportation using fossil fuels (both private and public), biomass burning and domestic fuels, landfills, wastewater treatment and agriculture.

With regards to biological invasive flora, these have had diverse and profound effects on every aspect of South African society (DFFE, 2021). They pose a danger to socioeconomic sustainability, they have made droughts, floods, and wildfires more severe, and have resulted in large losses in forestry, agriculture, and pastoralist industries. To date. a quarter of South Africa's overall biodiversity loss is attributable to biological invaders. The annual budget of the South African government for management is well over 1 billion ZAR. South Africa provides a global example of the effects of and the potential responses to biological invasions due to its rich and diverse cultural and biological variety, as well as its long history of attempts to control, manage and research foreign species. Regarding the integration of efforts to eradicate invasive plants with the efforts to reduce poverty, using traditional [biological control], and its ground-breaking Alien and Invasive Species (A&IS) Regulations of 2014, South Africa has adopted a position as a global leader in biological invasion control. The South African National Biodiversity Institute (SANBI) has been tasked to submit a report on the state of biological invasions and their management in South Africa every three years as part of the A&IS Regulations.

The coastal environment of South Africa is a valuable and diverse national resource that offers inhabitants significant social and economic opportunities. As a result of this, coastal residents have come to rely heavily on these resources for transportation, food, leisure and business opportunity (DFFE, 2021). Additionally, coastal resources have aided in the growth of the local economy and the creation of jobs in coastal areas. The coastal environment of South Africa is therefore:

- An economic place where commercial, recreational and subsistence activities take place,
- A social place where people enjoy themselves, go to relax and find spiritual peace,
- A biophysical place where land, sea and air meet and interact, and where beaches, sand dunes, rocky headlands and estuaries support a wide range of coastal biodiversity.

The importance of these three elements is underscored by the fact that they are interdependent with the social and economic value of coastal systems, which is largely reliant on the wellbeing and productivity of the biophysical element (GCIS, 2022). Without regulatory services, it is projected that coastal resources provide around R57 billion (US$ 5.7 billion) to the South African economy. In South Africa, the direct economic benefits from coastal resources are thought to account for about 35% of the nation's annual Gross Domestic Product (GDP). The development of ports and harbours, attractive lifestyles and the recreational and tourism options provided by coastal locations are only a few examples of the direct economic benefits. Additionally, the coast offers intangible economic advantages like erosion control from dunes and high cliffs that shield both the built-up and natural features along the coast (like roads, buildings and farmlands) from the damaging effects of waves and wind, as well as waste assimilation, detoxification and recycling through coastal wetlands, forests and grasslands.

According to the State of the South African Marine Fishery Resources 2020 report, there were 61 reported fish stocks in 2020 compared to 43 in 2012. Several linefish species (black musselcracker, dageraad, Roman, and white stumpnose), five species of skate (which replace the generic "skate" in the 2016 report), octopus, East Coast round herring and two species of shark (oceanic whitetip and great hammerhead) are among the species that are included for the first time. Some other linefish species (elf and white steenbras), requiem sharks and other species are included in the 2016 report but excluded in the 2020 edition.

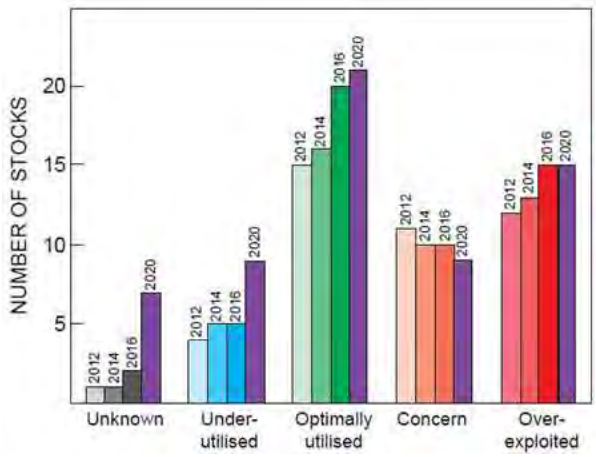

Figure 1-3: Number of fish stocks from 2012 – 2020 (DFFE, 2021)

According to the 2020 assessments, 39% of stocks are regarded to be of concern (orange and red categories), compared to 61% of stocks that are not considered to be of concern (blue and green categories). These numbers show progress over the previous eight years, with 46% of stocks deemed insignificant in 2012, 49% in 2014 and 52% in 2016.

South Africa's forests cover approximately 122 million hectares (ha), or 1 219 912 square kilometres (1.22 million km^2). A little over 40 million acres, or roughly 32.7% of the nation's land surface, is covered by forests. Even though more than a third of the country's land surface is covered by forested vegetation, South Africa is typically referred to as a "low forest cover" country. South Africa is considered a mega-biodiverse nation, ranking amongst the most biodiverse countries in the world, despite its "low forest cover" designation. The natural forest biome has the largest plant diversity per hectare of all seven biomes while being the smallest (less than 500 000 ha) and most fragmented (with 418 species per ha compared to 98 species per ha for the fynbos biome). There are three primary types of forests in South Africa: native forests (492 700 ha), commercial plantations (1.19 million ha) and woodlands (39 million ha).

1.4 Climate

South Africa, which is in a subtropical climate, benefits from a temperate temperature due to the inner plateau's altitude and the ocean's influence on three of its four sides (GCIS, 2022). The country is dry since it receives approximately 500 millimetres of rain on average each year. Except for the South-Western Cape, the majority of South Africa is in the summer rainfall zone, with the rainy season running from November to March and the dry season from May to September (Grab and Knight, 2015). Typically, summers are humid and warm in the east coast, and dry and extremely hot in the west and north. Most tropical-temperate troughs and easterly tropical air flow over the interior are linked to summer rains.

According to the South African Weather Services (SAWS) (2021), temperatures in South Africa have been moderately warm compared to years before. This can be attributed to the country's overall high rainfall levels. Based on the data from 26 climate stations, the annual mean temperature anomalies for 2021 were, on average, marginally higher than the reference period (1981–2010), making it roughly the 13th hottest year on record since 1951. The country is shown to be warming by 0.16^{0}C every decade, which is statistically significant at the 5% level. Additionally, the rainfall in 2021 was notable for rainfall that was far above average throughout a large portion of South Africa. In the summer of 2021–2022, El Niño-Southern Oscillation (ENSO) was in a La Nina phase, which is characterised by rainfall that is above average in most of the summer rainfall zones.

Due to the good rains in the early summer rainy season of 2021/22, notably from November onwards, the area of South Africa experiencing drought fell even further over the previous year. Nevertheless,

there were still certain regions in the western and southern interior that could be regarded as being rather dry, demonstrating the persistence of the long-term drought in some sections of the Northern and Eastern Cape (which in some places lasted for almost a decade).

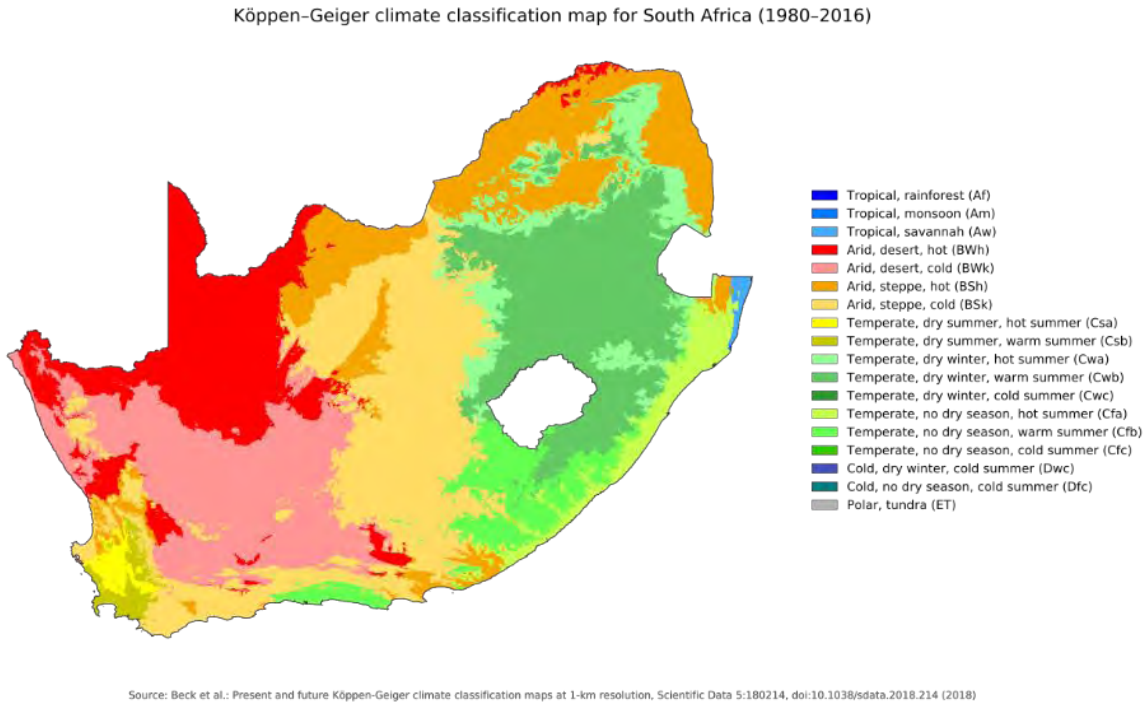

Figure 1-4: Climates in South Africa

The central plateau's elevation, at 1 694 metres, prohibits summertime highs to rise over 30°C, which is where the city of Johannesburg is located. For the same reason, it is possible for some areas to experience winter nights that are at or below freezing. As a result, South Africa's coastal regions experience a warm winter. Letaba, in the Limpopo region, is the hottest locality in South Africa with a mean annual temperature of 23.7°C and an average annual maximum temperature of 30.7°C.

Conversely, Buffelsfontein in Molteno in the Eastern Cape is the coldest location in the entire country, with an average annual low temperature of 2.9°C and a mean annual maximum temperature of 11.5°C. With an average yearly rainfall of 2004 mm (measured over a 60-year period), Matiwa in Limpopo is the wettest location. In addition, Alexander Bay in the Northern Cape is the driest place in the nation with an average annual rainfall of only 46mm, whilst Cape Point in the Western Cape is the windiest place, with only 2% of the year's hours enjoying calm conditions. 42.1% of the wind that blows is more than 8 m/s, with the average wind speed being 6.9 m/s.

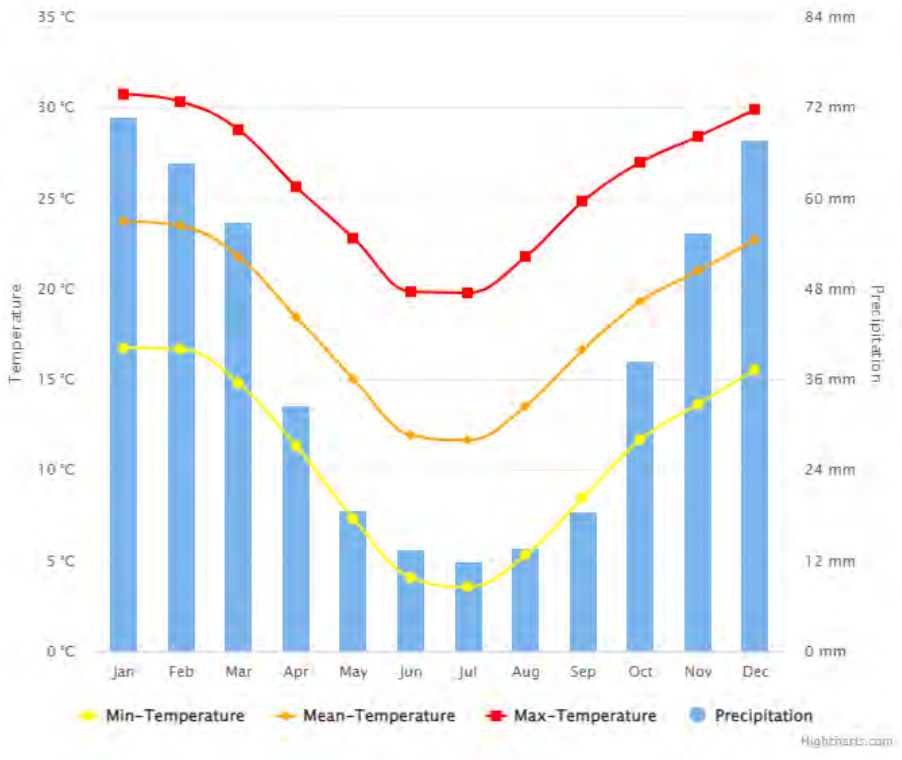

Figure 1-5: South Africa's monthly climatology of Min-Temp, Mean-Temp, Max-Temp & Precipitation from 1991 to 2020 (SAWS, 2021)

The Fourth South African Climate Change Tracking Report (2023), which provided a narrative of the country's climate realities (narrative 0), revealed that climate variability has long played a significant role in agriculture-related droughts and the effects of extreme events, primarily flooding, on communities that are vulnerable and exposed (DFFE, 2023).

The evidence is mounting that climate change is further enhancing the frequency and magnitude of climate impacts through more frequent extremes (such as droughts and floods), higher temperatures, and in some cases, more intense rainfall events. Rapid urbanisation and associated informal housing, lack of infrastructure, as well as rural land degradation contribute to increasing impacts from climate variability.

Although regional climate variability and change are complicated, trends show that extreme rainfall events are becoming less common. Although South Africa's shoreline is less susceptible to sea level rise than some other nations, there is still significant local exposure, especially in high-value residential and commercial sectors. Though it is difficult to directly link this to climate change, South Africa's blue economy is considerable in some areas, and the effects of changing wind patterns and rising oceans are starting to show.

To counter these shifts, quick and proactive solutions in the form of adaptation as well as continued strategic development (such as formal housing and infrastructure) are required. However, anticipated changes hint towards a continuation and possibly even an acceleration of both ocean and atmospheric changes.

A summary of climate variabilities is provided below:

Indicator 0.1: Annual Mean Extreme Temperatures

Figure 6 below demonstrates that South Africa's temperatures closely correspond to those of the rest of the world, with more rapid warming occurring in the interior provinces and slower warming occurring in KwaZulu-Natal, the Eastern Cape and the Western Cape. Analysis of the frequency of really hot

days (days > 95th percentile), as determined by SAWS, shows that the number of hot days per year is steadily rising in all provinces.

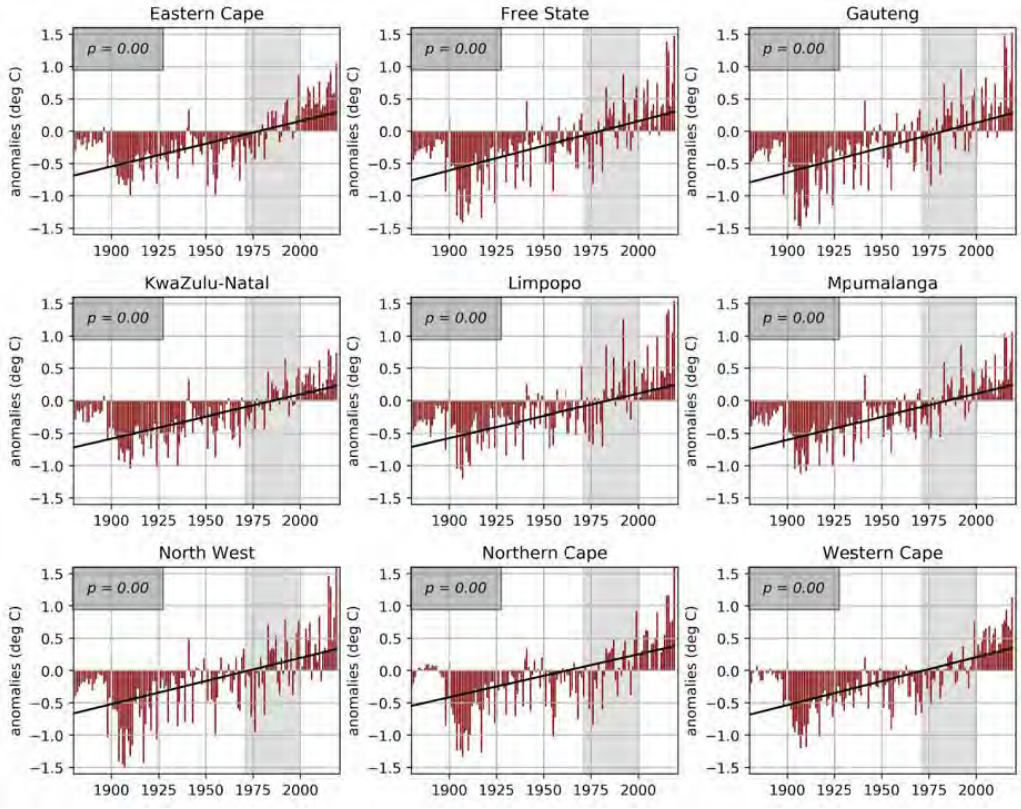

Figure 1-6: Average annual temperature anomalies between 1875 and 2025 for South Africa based on homogenised station data from SAWS (DFFE, 2023).

Indicator 0.2: Annual Total Rainfall

Since 2012, the country has seen below-average rainfall, with 2015/2016 being particularly dry due to the significant El Nino event during that time. Since 2016, some provinces (Mpumalanga, Northwest, Gauteng and Limpopo) have recovered slightly, but others have experienced persistent dryness. Strong inter-annual variance is visible in all provinces, and Figure 7 below shows that for the entire period from 1981 to 2019, KwaZulu-Natal, the Eastern Cape and the Western Cape all have statistically negative trends in total annual rainfall.

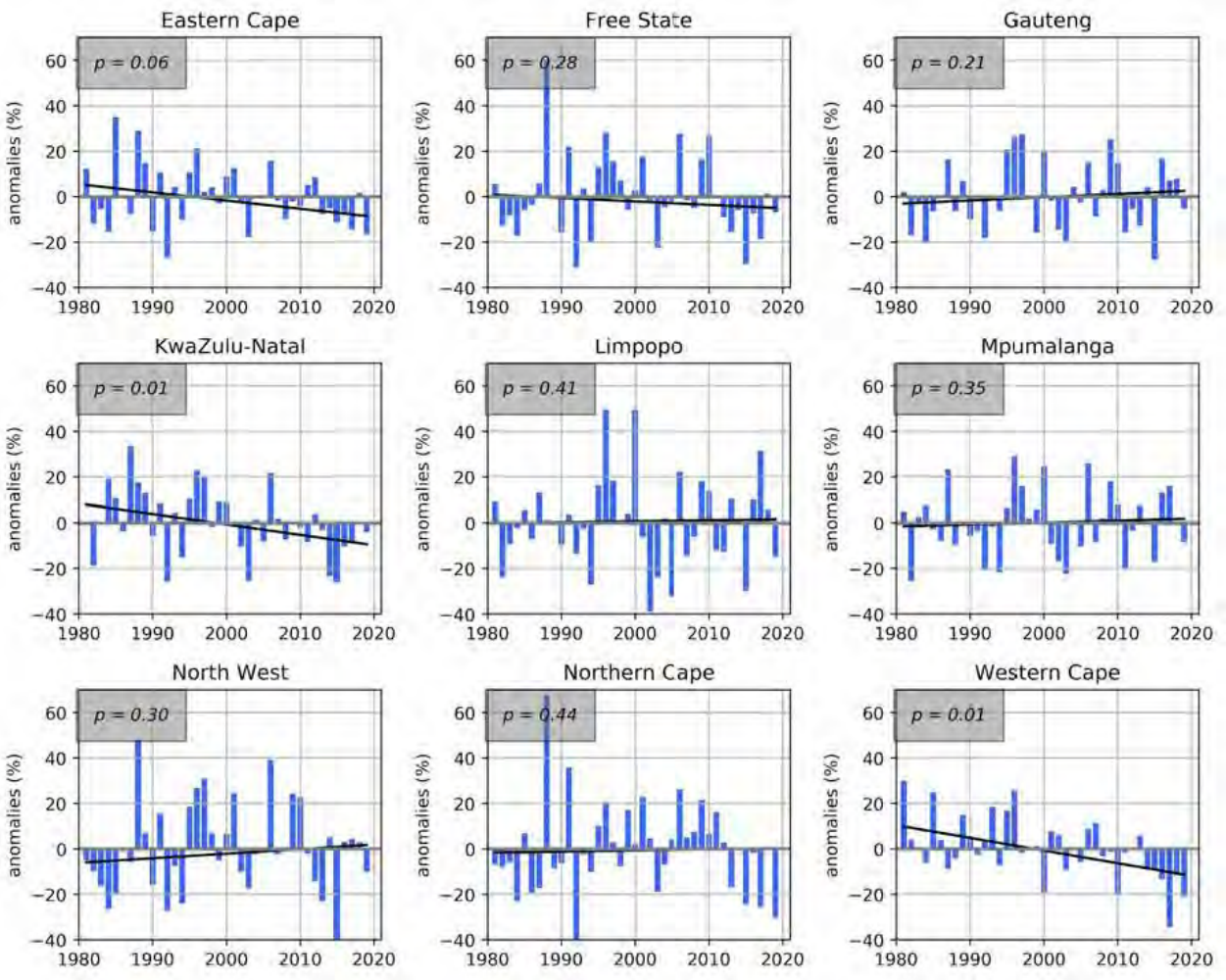

Figure 1-7: Total annual rainfall as percentage of historical averages (1981-2019) for July-June for all provinces except Western Cape (Jan-Dec). The trend (black line) and significance level (p) were calculated using the Theil-Sen estimator method.

Indicator 0.3: Annual Rainfall Extremes

In agreement with recent publications, the majority of South Africa currently does not show any recent increases in high rainfall events, but some regions do, including the Western Cape, Eastern Cape and KwaZulu-Natal.

The results presented below imply that rather than the increased frequency of intense rainfall episodes, the growing impact of intense rainfall may be more closely related to increased exposure and vulnerability. The size and ease of this analysis, however, limits this conclusion. Extreme rainfall events frequently have a small spatial scope and a short duration. Such occurrences (a) will not always be reflected in weather station records or even satellite proxy data, and (b) will not have a significant impact on statistics at the provincial level.

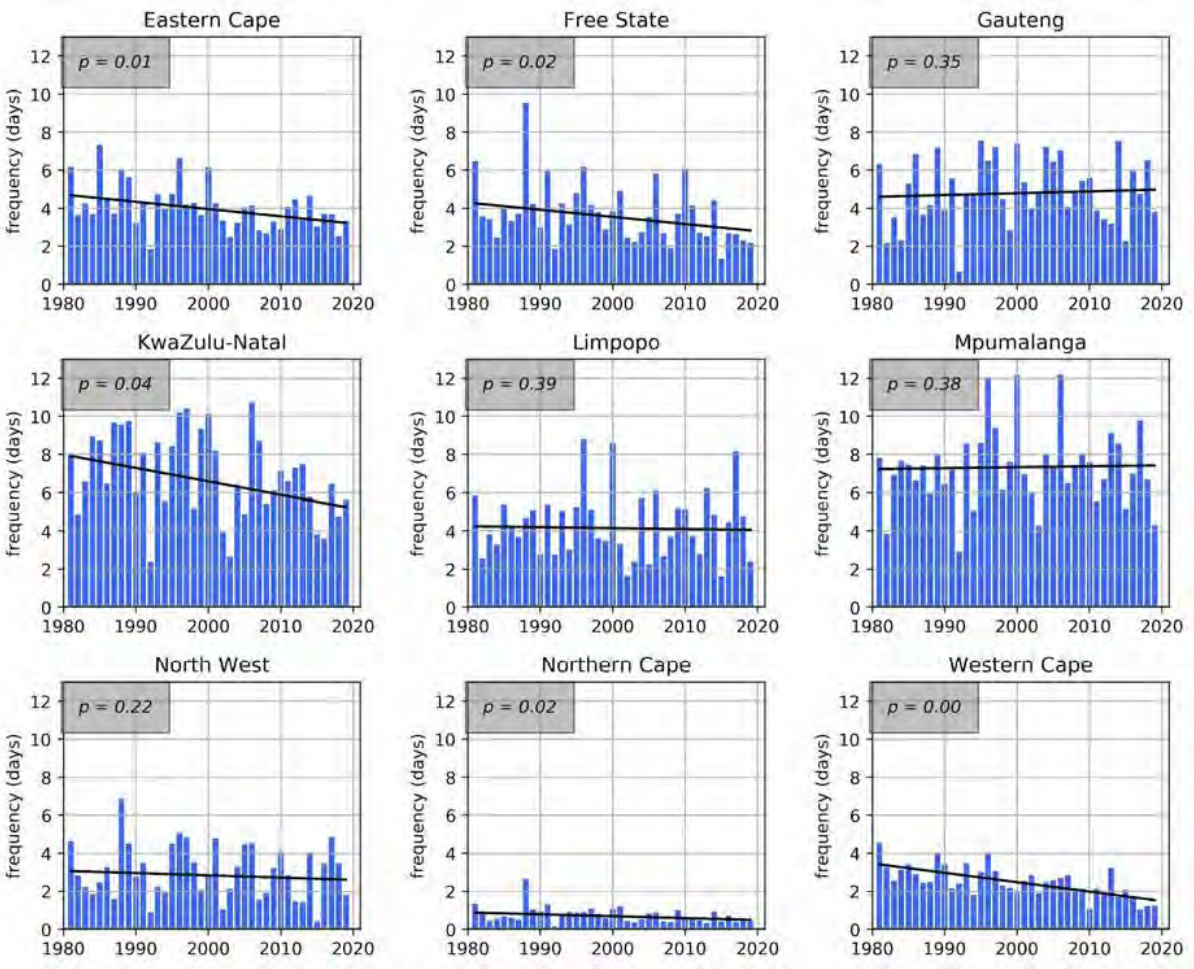

Figure 1-8: Frequency of extreme rainfall days from 1981 - 2019 (days with rainfall above the 95th percentile) per year for all provinces. The trend (black line) and significance level (p) were calculated using the Theil-Sen estimator method.

Indicator 0.4: Sea Surface Temperature Anomalies

The complicated patterns of abnormal warming or cooling over the regions that are shown by annual mean sea surface temperatures, vary dramatically from year to year. Results for the five coastal zones and the substantial Agulhas Current system area also demonstrate the significant yearly fluctuations. The coastal region of the Eastern Cape and KwaZulu-Natal, particularly the Agulhas Current system area, is showing signs of warming. However, as this pattern only lasted from 1981 to 2019, it may be connected to longer-term variability across several decades.

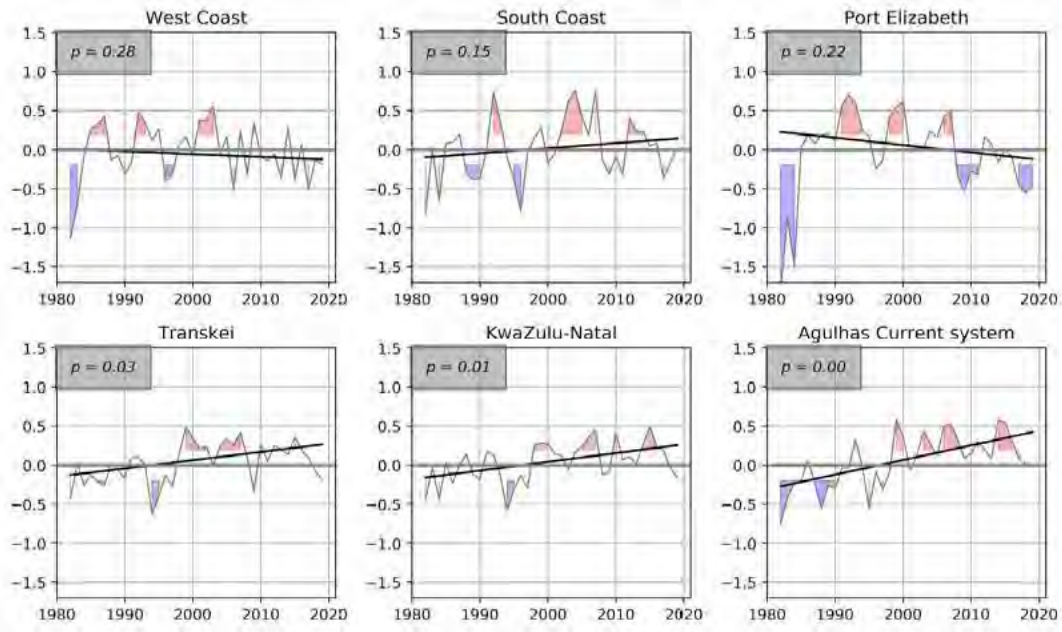

Figure 1-9: Sea surface temperature anomalies (°C) for the five coastal zones and the large Agulhas Current system zone. Anomalies calculated from the 30-year climatology (1982-2019). The trend (black line) and significance level (p) were calculated using the Theil-Sen estimator method.

Indicator 0.5: Wind Anomalies

The southerly wind vector is strongest offshore to the north and weakest along the south coast, according to the climatology of the 10-meter zonal wind component (note that this is only the north-south component of the wind and does not present the actual wind speed). This southerly wind vector dominates over the entire west coast ocean domain.

In some places, the southerly wind component's strength changes from year to year by as much as 0.8 m/s. Along the whole west coastal zone, the southerly wind component was stronger than the average in 2017 and weaker than the average in 2018, while in 2019, the wind was stronger over the northern and weaker over the southern portions of the study region. For any of the three west coast zones, there are no statistically significant trends in the zonal wind annual anomalies at the annual scale.

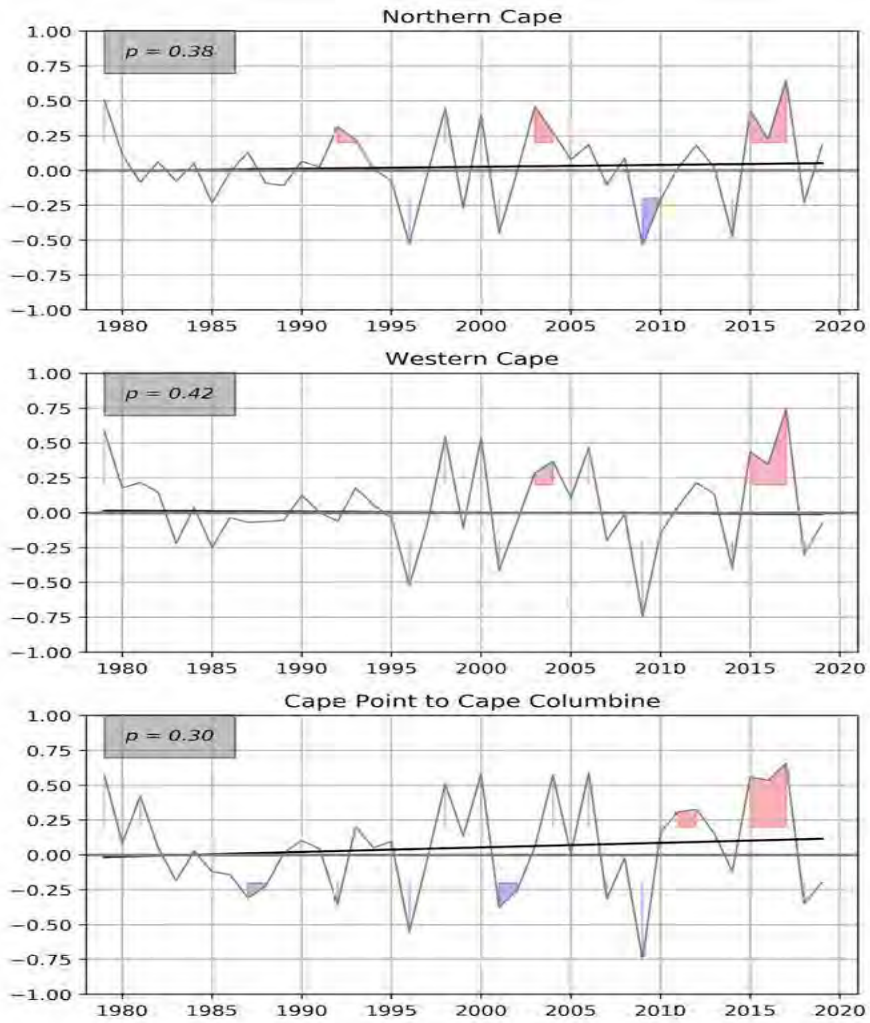

Figure 1-10: Time series (1979-2019) of the annual mean anomalies in the 10-metre zonal (north-south) wind component for three zones along the west coast of South Africa. The trend (black line) and significance level (p) were calculated using the Theil-Sen estimator method.

Indicator 0.6: Ambient Carbon Dioxide (CO_2) Concentration

The average worldwide CO_2 concentration has clearly increased over the past 40 years, rising by about 70 parts per million (ppm). Despite being based on a shorter time period, the Cape Point data appears to closely track the overall patterns.

South Africa's terrestrial and marine systems are under stress, the climatic zones around the country are changing and ecosystems and landscapes are deteriorating (RSA VNR, 2019). The ongoing heatwaves and droughts are proof of the enormous difficulties posed by climate change. Due to extreme weather (especially drought) and human activity, over 11% of South Africa's land has been degraded. Given that it is expected that the average temperature would rise twice as quickly as temperatures elsewhere in the world, South Africa is likely to experience some climate change effects more severely than other countries.

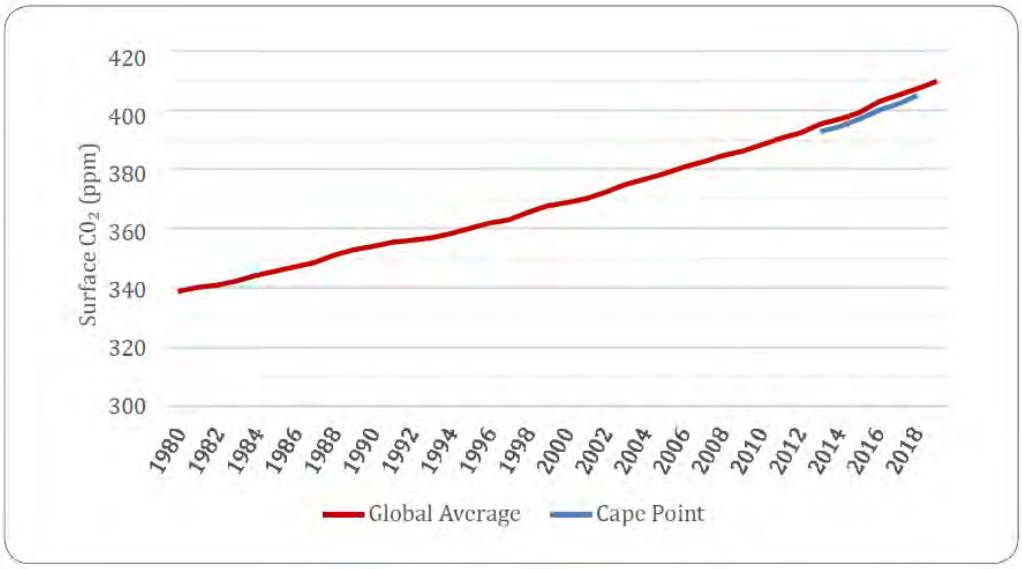

Figure 1-11: Surface CO_2 concentrations in parts per million (ppm), global average versus Cape Point station measurements.

The 2017 Knysna and Plettenberg Bay Fires

The Western Cape province experienced 17 000 fires in the 2016–17 fire season, which led to 142 fatalities. 2 000 of the 17 000 fires, harming 5 900 persons, were reported in informal communities. In terms of the Knysna and Plettenberg Bay fires, of these fires, were extremely catastrophic. On June 7, 2017, a fire broke out in the Western Cape's Knysna region, causing havoc and devastation on a magnitude that had never been seen before within a local government in South Africa. Sadly, the Knysna fire resulted in fatalities as well as the destruction of substantial service infrastructure and homes worth millions of rands.

Figure 1-12: Knysna fires of 2017 (Maarsingh, 2017)

More than 600 buildings were destroyed by flames between June 6 and June 10 in Knysna and Plettenberg Bay as a result of the exceptionally challenging firefighting conditions brought on by gale-force winds surpassing 90 km/h. On June 8, 2017, there were about 28 fires recorded in the region. Seven people lost their lives, hundreds of homes were damaged, and thousands of hectares of land were burned. Infrastructure damage was expected to be worth about R136 million, according to the preliminary analyses. However, insurance pegged the cost of the damage to private property to be between R4 billion and R5 billion. Due to the destruction of communication towers during the fire, cellular communication was lost for more than 20 hours, making it difficult to communicate.

2022 KZN floods

Between 8 April to 12 April 2022, record-breaking rains inundated the region around the port city of Durban in the KwaZulu-Natal Province, South Africa (IFRC, 2022). The floods washed away infrastructure, land, houses and livelihoods. Sadly, 435 people lost their lives and to date, 80 people are still reported missing. A total of 19113 households with 128 743 people have been affected by the disaster and on the night of 18 April 2022, the president of South Africa declared the KZN floods as a national state of disaster to maximise national and provincial coordination to respond to the urgent crisis in the affected communities.

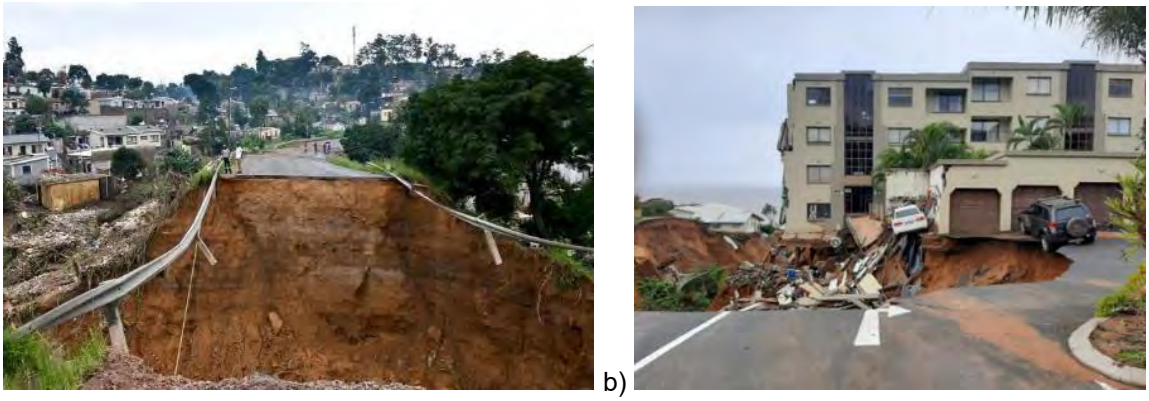

Figure 1-13: a) Destroyed bridge in KwaZulu Natal due to floods (Tlape, 2022), b) Heavy rain flood damage in KwaZulu Natal (eThekwizi Municipality, 2022)

The hardest-hit areas were rural communities, particularly on steep hillsides with little or no infrastructure to shield people from the elements. These locations were informal settlements built close to rivers, below flood lines and on flood plains. Many of the homes were constructed with simple materials like tin sheets, wood (often salvaged) and mud and regrettably, the majority of these buildings and all of their contents were entirely wiped away. Rain and flooding struck during the night while people were asleep, heightening the danger and dread of the situation. The flooding also had an impact on vital infrastructure, including important roadways, water treatment and supply facilities, communication and electrical systems. This damage significantly hampered rescue and recovery efforts with infrastructure in the town having been severely damaged, including 600 schools and 84 medical facilities.

The SAWS issued an early warning level 10 Alert of disruptive rainfall in the municipal areas of Hluhluwe, EThekwini, Jozini, KwaDukuza, Mandeni, Maphumulo, Mkhambathini, Mthonjaneni, Mtubatuba, Ndwedwe, Nongoma, Ulundi, Umdoni, Umhlabuyalingana, uMhlathuze, uMlalazi and uPhongolo.

The SAWS Annual State of the Climate 2021 report also covers the following notable climatological events in the country, which occurred in 2021. The first incident triggered by extremely high December rainfall, led to a number of adverse effects. Although only the most notable effects are mentioned as a result of flash floods that caused extensive damage and destruction on January 1, hundreds of families in Piet Retief, Mpumalanga, were left homeless. Several houses had their windows damaged, their roofs blown off and roads were also heavily impacted. On the 4th of January, following a period of severe rain the second incident, caused a man to be carried off a low-lying crossing bridge near Hengelaar and Seekoei roads in the Roodeplaat area of Tshwane, Gauteng. The next morning, 5th January, his vehicle was recovered and the body of the man was discovered about a km from where the car was last seen. In addition, a taxi and another car were swept away by floods along the R577 road near Thorncliff Mine on the border of Mpumalanga and Limpopo Province on the 7th of January. Both the taxi and the car were recovered at the riverbank, but both occupants were missing.

Following torrential rain that hit Mthatha in the Eastern Cape on the 9th of January, 44 people, including six children, were admitted to Mthatha General Hospital. Furthermore, when homes collapsed during a period of heavy rain, people from 77 households in the King Sabata Dalindyebo municipality were left homeless and 15 additional families were left largely impoverished. The storm claimed the lives of some animals, including sheep, goats and chickens. Infrastructure like energy power cables and electric metre boxes, as well as the Siyazama Ntilini Pre School were damaged. In Mhlontlo ward 17, the Gqunu Bridge was washed away.

1.5 Population

In South Africa, the projected mid-year population in 2022 was 60.6 million with 31.0 million people (approximately 51.1% of the population), being female (StatsSA, 2022). Approximately 81% of all South Africans are black Africans, who make up the majority (49.1 million) of the country's population. 4.6 million people identify as white, 5.3 million as coloured, and 1.5 million as Indian or Asian. These statistics are presented in full in the table below.

Table 1-2: Mid-year population estimates for South Africa by population group and sex, 2022 (Source: StatsSA)

Population group	Male		Female		Total	
	Number	% distribution of males	Number	% distribution of females	Number	% distribution of total
Black African	23 985 479	81,0	25 085 330	81,0	49 070 809	81,0
Coloured	2 601 932	8,8	2 737 987	8,8	5 339 919	8,8
Indian/Asian	794 882	2,7	760 114	2,5	1 554 996	2,6
White	2 242 589	7,6	2 396 679	7,7	4 639 268	7,7
Total	**29 624 882**	**100,0**	**30 980 110**	**100,0**	**60 604 992**	**100,0**

**Due to rounding totals may not add up to 100%*

In 2022, male and female life expectancy was predicted to be 60 and 65 years, respectively. According to estimates, there was an average of 24.3 infant deaths for every 1 000 live births in 2022. The estimated overall HIV prevalence rate in South Africa's population is at 13.9% and about 8.5 million individuals were estimated to be HIV-positive in 2022, with about 19.6% of adults between the ages of 15 and 49 being HIV positive.

The age structure and distribution of the population in a province are shaped by migration, which is a significant demographic phenomenon. COVID-19 travel limitations have had an effect on migratory patterns since March 2020, leading to a decrease in the number of international migrants coming into South Africa. The highest influx of migrants was estimated to arrive in Gauteng and the Western Cape between 2021 and 2022, totalling 1 443 978 and 460 489 respectively.

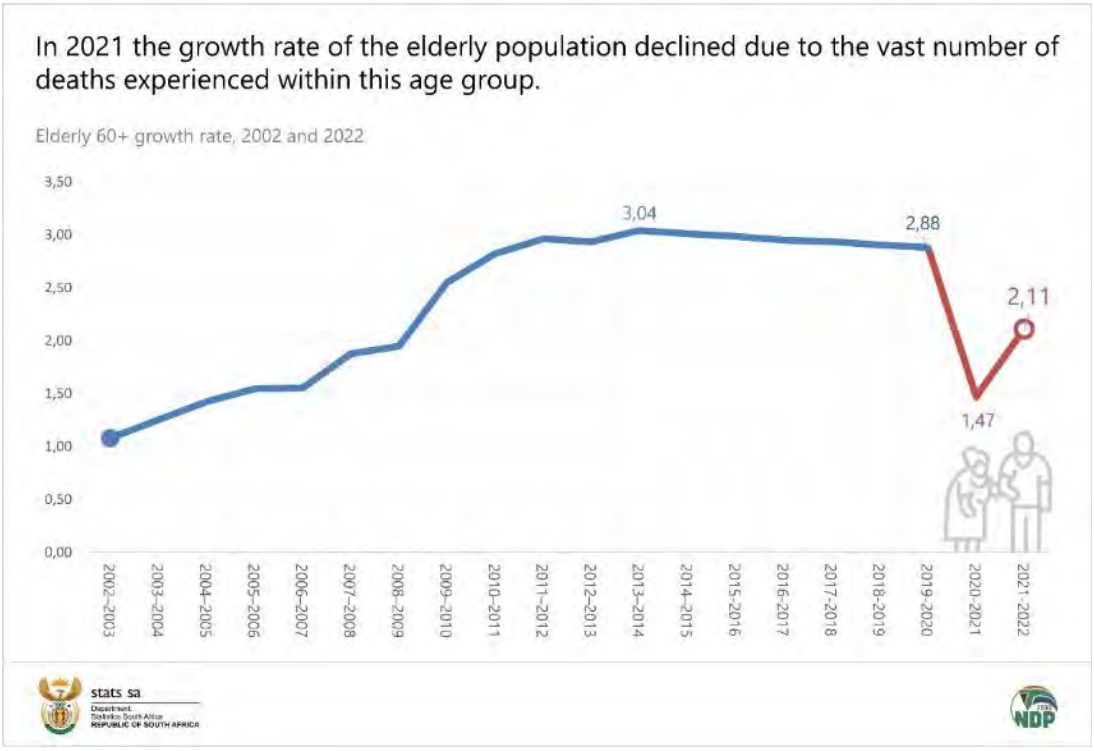

Figure 1-14: The growth rate of the elderly population in South Africa (StatsSA, 2021)

With over 16.1 million inhabitants (26.6% of the total population of South Africa), Gauteng continues to have the highest population proportion. With an estimated 11.54 million residents (19.0%), KwaZulu-Natal is the province with the second-largest population and the Northern Cape continues to have the smallest percentage of South Africa's population, with a population of roughly 1.31 million (2.2%). 17.01 million people, or about 28.07% of the population, are under the age of 15, while 5.59 million people, or about 9.2%, are 60 years or older. Limpopo (33.6%) and the Eastern Cape (32.7%) are the provinces with the highest proportion of children under the age of 15. Policies and strategies to care for the needs of this ageing population should be a priority, since the proportion of elderly South Africans aged 60 and older is continually rising over time.

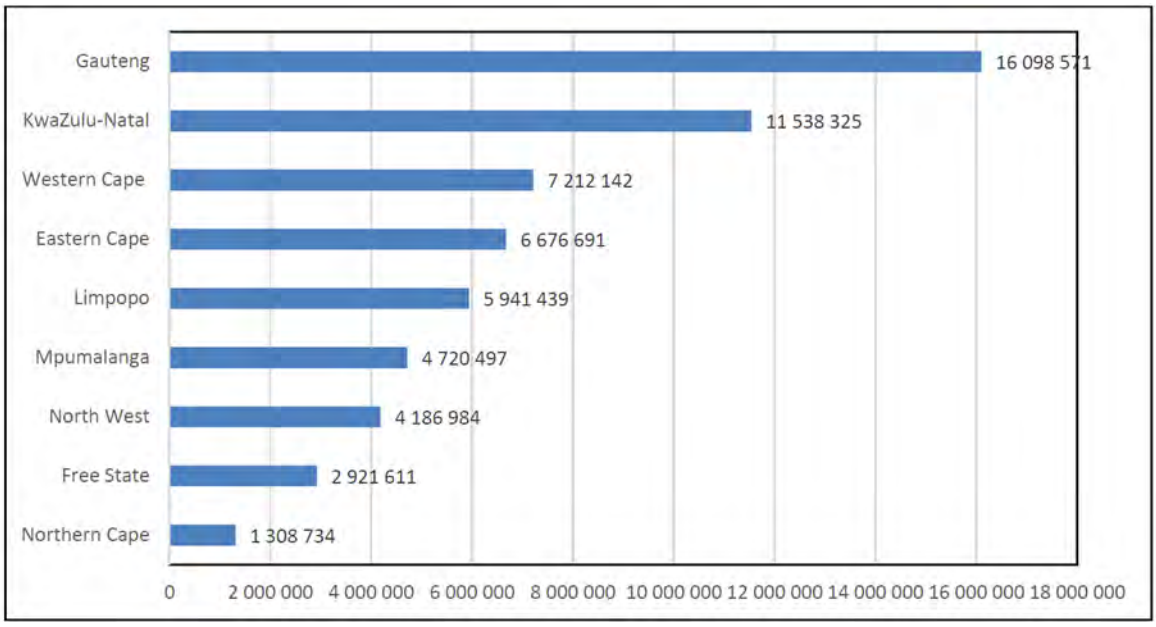

Figure 1-15: South Africa's provincial mid-year population estimates 2022 (StatsSA, 2022)

1.6 Economy

South Africa is a middle-income emerging market (DMRE, 2021), with the following key economic sectors:

- Agriculture,
- Energy,
- Manufacturing,
- Mining,
- Tourism,
- Transport.

South Africa's GDP fell by 1.3 % in the fourth quarter (October–December) of 2022 after increasing in the previous quarter (StatsSA, 2023). The South African economy increased for a second year in a row, rising from R4.50 trillion to R4.60 trillion between 2021 and 2022. The GDP increased to an all-time high in 2022, but since the pre-pandemic estimate of R4.58 trillion in 2019, the economy has only risen by 0.3%, which is lower than the country's population growth of 3.5% during the same period.

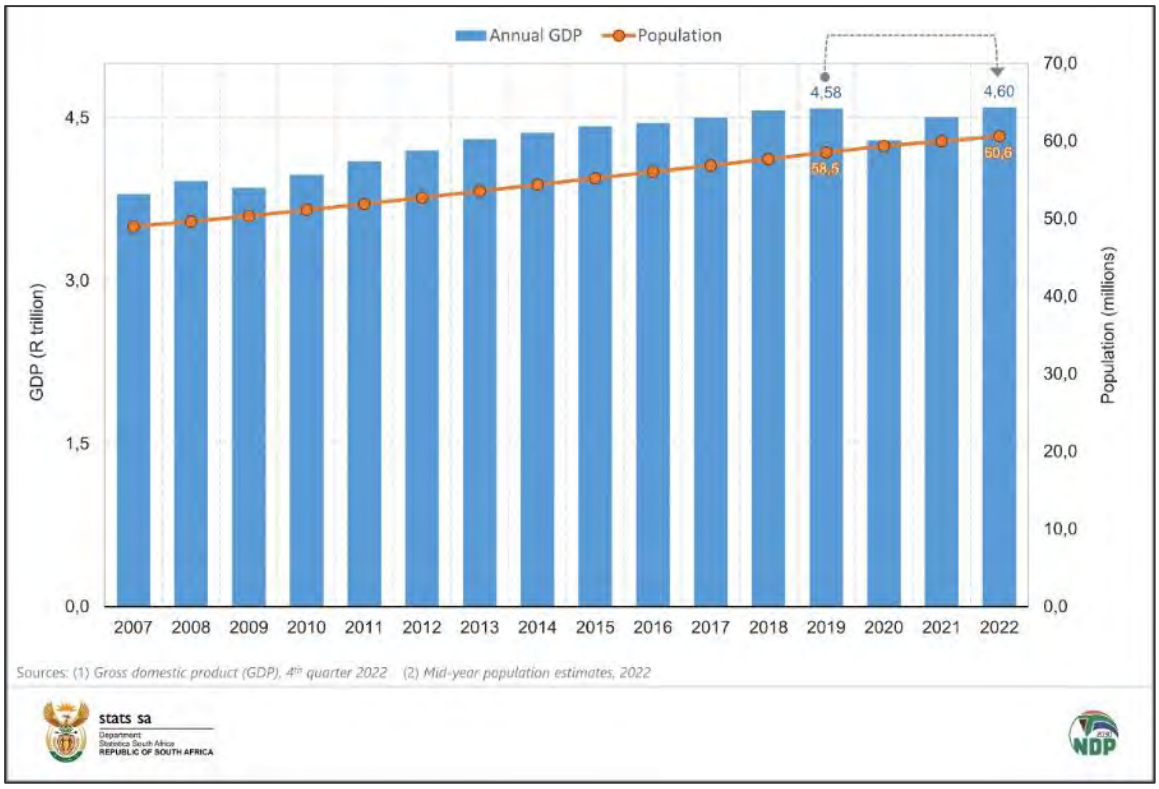

Figure 1-16: South Africa's GDP between 2019 and 2022, which increased by 0.3% (StatsSA, 2023)

Finance, trade, mining, agriculture, manufacturing and general government services were the primary restraints on growth. The industry growth rates for Q4 in 2022 are shown in Figure 17 below, where. seven out of the ten industries experienced a decline in the fourth quarter. Due to decreased economic activity in auxiliary activities, insurance and pension funds and financial intermediation, the largest sector in the South African economy, banking, real estate and business services, experienced a 2.3% decline, which was the main cause of the GDP decline and a 0.6% reduction in GDP growth.

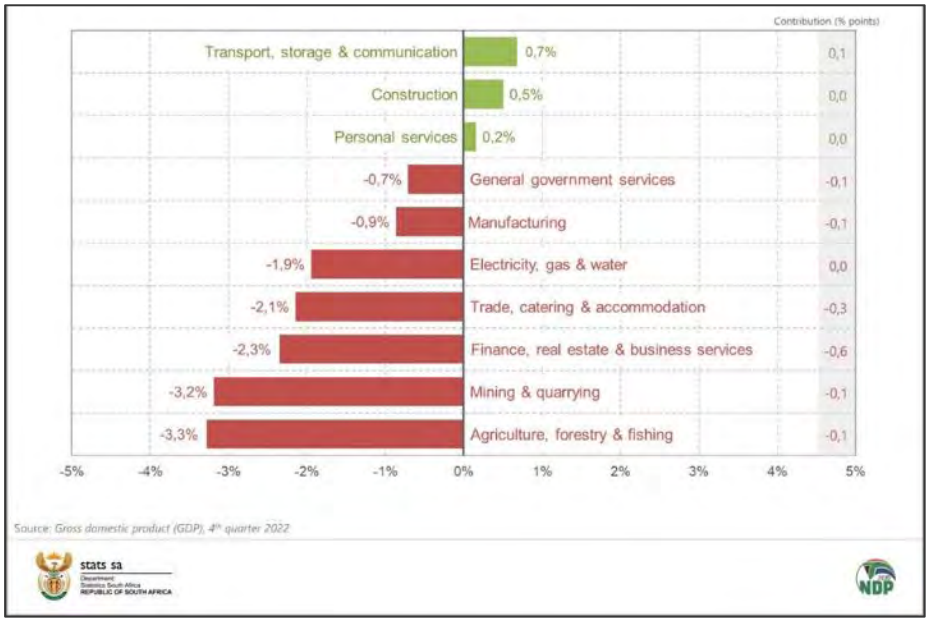

Figure 1-17: The industries contracted in 2022: Q4 (StatsSA, 2023).

With a decrease of 2.1%, the trade, catering and accommodation sector was the second biggest negative contributor on growth, with the reduction in wholesale trade being the main cause. The

production of diamonds, iron ore, and Platinum Group Metals (PGMs) declined, which reduced mining output. Lower levels of electricity production and consumption (mostly because of load shedding) and water were an obstacle to economic activity in the electricity, gas and water delivery industry. The agriculture sector experienced the highest decline (-3.3%) in the quarter, mostly due to lower output levels for field crops and horticultural goods. The fourth quarter's strong areas included construction, personal services, transportation, storage, and communication, with the highest positive impact being seen in transport, storage, and communication, which increased by 0.7% and added 0.1 percentage point to growth. Increased economic activity in the passenger land transportation, air transportation, and communication services was mostly responsible for this increase.

According to the National Treasury (2023), the South African economy is predicted to have expanded by 2.5% in real terms in 2022. However, the actual GDP growth for 2023 has been lowered down to 0.9%, partly because of frequent and prolonged load shedding. The rate of growth will be 1.4% on average over the following three years i.e., 2024 to 2026. Over the Medium-Term Expenditure Framework (MTEF) period, it is expected that the consolidated budget deficit will continue to shrink, reaching 3.2% in 2025–2026 and in the same period, the gross loan debt, which includes the Eskom debt-relief deal, will stabilise at 73.6% of GDP. From R307.2 billion in 2022–2023 to R397.1 billion in 2025–2026, debt servicing costs will increase.

The gross tax income for 2022–2023 is anticipated to exceed R1.69 trillion based on revenue patterns and tax proposals, which is R93.7 billion more than the 2022 Budget forecast. A R13 billion tax cut helps with the shift to sustainable energy, boosts the availability of electricity and lessens the effects of persistently high gasoline prices. According to the medium-term spending plans, the combined spending budget for the next three years totals R7.08 trillion. The social wage, which includes public spending on health, education, housing, social protection, transportation, employment and local amenities, accounts for the majority of this sum of the combined spending budget, approximately R3.6 trillion.

1.7 Energy

According to the NDP (2011), South Africa shall have an energy sector that fosters economic development and progress by investing enough in energy infrastructure by the year 2030. The plan also anticipates that by 2030, at least 95% of the population will have access to grid or off-grid electricity, and that South Africa would have a sufficient supply of energy and liquid fuels to ensure that economic activity and welfare are not disturbed. The extraction, transformation and distribution of energy resources and services across the economy are vital to the health of the South African economy and are significant economic sectors.

This section contains an overview of the Integrated Resource Plan 2019 (IRP 2019). The NDP 2030 of South Africa, which provides a long-term plan for the country's development, serves as the foundation for the IRP. It outlines a desirable state in which poverty, unemployment and inequality are all abolished, and all South Africans can enjoy a reasonable standard of living. Electricity is one of the key elements of an acceptable standard of living.

The IRP is also a development plan for the electricity infrastructure based on the least-cost electricity supply and demand balance, taking into account energy supply security and the environment (minimising negative emissions and water usage), and it was anticipated at the time of its promulgation that the IRP would be a "living plan" that would be updated on a regular basis. The optimum generation technology needed to fulfil anticipated demand increase through 2030 was indicated by the published IRP 2010–2030. It included government goals for accessible electricity, lower greenhouse gas emissions, less water use, a variety of electrical generation sources, localisation and regional growth.

Since the IRP 2010–2030 was promulgated, the following capacity developments have taken place:

- A total 6 422 MW under the Renewable Energy Independent Power Producers Programme (REIPPP) has been procured, with 3 876 MW becoming operational and being made available to the grid.
- IPPs have commissioned 1 005 MW from two Open Cycle Gas Turbine (OCGT) peaking plants.
- Under the Eskom build programme, the following capacity has been commissioned: 1 332 MW of Ingula pumped storage, 1 588 MW of Medupi and 800 MW of Kusile coal power generation and 100 MW of Sere Wind Farm.
- In total, 18 000MW of new generation capacity has been committed to.

In addition to capacity growth, a number of assumptions have changed since the IRP 2010–2030 was published. The forecast for energy demand, the performance of Eskom's existing plants and the cost of new technologies are among the key assumptions that have changed.

As South Africa pursues a diversified energy mix that lessens reliance on a single or a small number of primary energy sources, the IRP also offers updates on the nation's energy mix. The current state of each energy source is listed below as at the time of publication:

- **Coal**: Beyond Medupi and Kusile, coal will continue to play a big part in South Africa's power generation as it makes up the largest base of installed generation capacity and the majority of energy produced.
- **Nuclear**: In 2024, Koeberg Power Station nears the end of its design life. South Africa has decided to extend the design life of its nuclear power programme and expand it in the future to prevent the extinction of nuclear power in the energy mix.
- **Natural Gas**: Gas-to-power systems such as Closed Cycle Gas Turbine (CCGT), Closed Cycle Gas Engine (CCGE), or Internal Combustion Engine (ICE) offer the flexibility necessary to support renewable energy sources. While there is a chance to pursue gas import options in the medium term, local and regional gas resources will enable scaling up with manageable risk levels. Exploration efforts are currently underway and need to be intensified to determine the amount of nearby viable shale and coastal gas.
- **Renewable Energy**: The opportunity to diversify the electrical mix, to provide distributed production, and to offer off-grid electricity is presented by Solar Photovoltaic (PV), wind, and Concentrated Solar-thermal Power (CSP) with storage. Additionally, the development of new sectors, the creation of jobs and localisation along the value chain all have enormous potential due to renewable technologies.
- **Hydro**: Run-off hydroelectric projects offer potential in the rivers of South Africa. These technologies have been demonstrated to be practical through many projects that rural communities have put into use.

Regarding energy storage, smart grid systems, energy storage and non-dispatchable renewable energy sources based on solar PV and wind, all work in harmony. Technology advancements connected to energy storage are upending the conventional power distribution model, and more renewable energy can be harnessed even if it may be produced at times of low demand. The issue can be solved by storage technologies, such as battery systems, compressed air energy storage, flywheel energy storage, hydrogen fuel cells, etc., especially in the context of South Africa, where over 6 GW of renewable energy have been introduced but the power system lacks the necessary flexibility or storage capacity.

Figure 18 below shows the share % of energy used by six major economic sectors in 2018 i.e., industrial, transportation, agriculture, residential, business, and public services (DMRE, 2021b). Unaccounted energy—energy that has not been assigned to a particular sector—is referred to as "non-specified" sector in the figure below. Due to South Africa's high energy intensity, the energy

sector is at the heart of the country's economy. Despite its recent electrical problems, South Africa has one of the highest rates of electricity access in sub-Saharan Africa and a well-developed electricity network. Electricity is a viable alternative for cooking in both urban and rural locations, and the country also depends on oil and gas for its energy requirements.

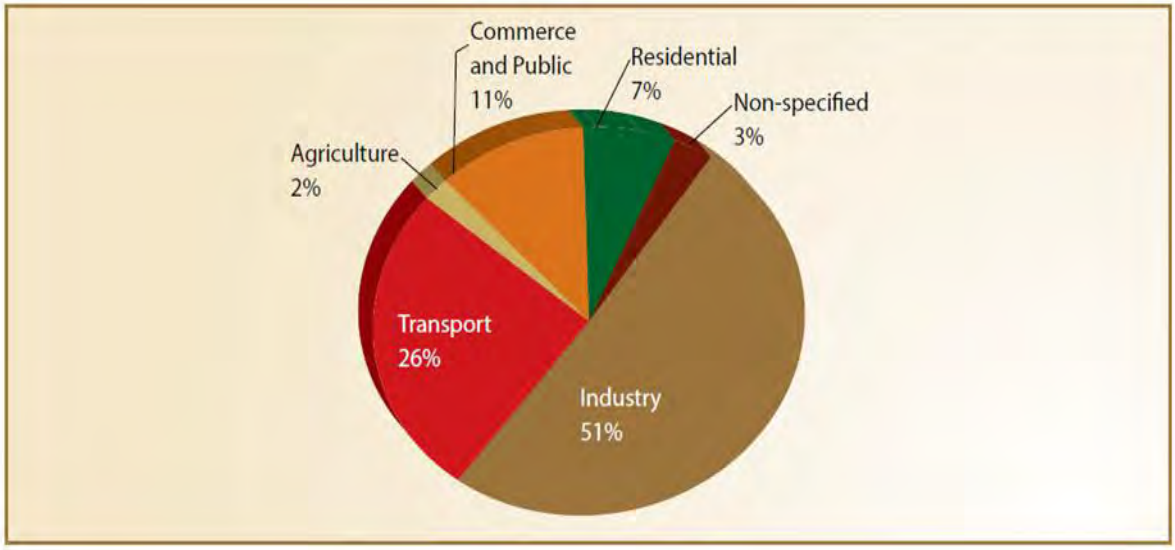

Figure 1-18: Energy demand per sector in 2018 (DMRE, 2021b)

More than 80% of the electricity produced is from coal, with renewable energy sources (except hydro) accounting for only 6.5% (CSIR, 2022). Over 80% of the system demand in the first half of 2022 came from coal-fired power generation, which continues to dominate the electricity mix:

- Coal energy contributed 81.3% (91.1 TWh)
- Nuclear energy contributed 3.8% (4.2 TWh)
- Renewable energy contributed 13.4% (15 TWh)
- Renewable energy contributed 6.5% (7.3 TWh) - excluding hydro
- The remaining 1.5% came from diesel (1.7 TWh)

More information on energy supply is provided for each energy source below (DMRE, 2021b):

- **Crude oil and Petroleum Products**: Due to the lack of reserves, South Africa imports about 90% of its crude oil from Nigeria, Angola and Saudi Arabia. The country produced roughly 3.2% of its fuel needs from petrol (GTL), 42.3% from coal (CTL) and 54.4% from crude oil during the processing stage. Although the majority of the country's petroleum products are refined domestically, certain petroleum products were imported to make up for the production gap.
- **Natural gas**: Sasol Gas transports natural gas from the Temane and Pande gas fields in Mozambique to South Africa via an 865-kilometre pipeline. The estimated amount of reserves in the Temane and Pande fields is 2.6 trillion cubic feet (TCF). The pipeline has a 240 million gigajoule (GJ) annual capacity. In South Africa, the primary energy source in 2018 was made up of 3% natural gas, where domestic natural gas production was only 12%, while imports were 88% of total production during that time.
- **Electricity**: Electricity produced by Eskom and Independent Power Producers (IPPs), together with imports from nearby nations, is delivered in bulk to distributors, such as major cities and other municipalities, as well as to industrial, commercial, residential and other users. In addition to one nuclear power station, Eskom owns and runs many coal-fired, gas-fired,

hydroelectric and pumped storage power plants. In 2018, local production made up 91% of the nation's total electricity supply, while net exports made up 5% of the total.

- **Coal**: Coal remains the country's main domestic energy source, and in the next two decades, its reliance on coal-based energy is not projected to shift dramatically. South Africa used a lot of coal in its own economy, but it also exported 24% of it in 2018, with comparatively few imports.
- **Renewables**: Through private sector investments in onshore wind, PV, CSP, biomass, landfill gas and small hydro technologies, the Renewable Energy REIPPPP aims to supply more power to the electrical grid. Onshore wind power now holds a 52% market share in terms of energy supply capacity per technology, followed by PV power (36%) and CSP (9%). Onshore wind power accounted for 60% of the REIPPPP electricity production in 2018, with photovoltaic power coming in second at 30%. The electricity generated by the REIPPPP included 10% and 1%, respectively of CSP and small hydro power. In total, 10 809 GWh was generated in 2018.
- **Nuclear**: In 2018, about 2% of the overall energy supply came from nuclear energy. The only nuclear power plant in South Africa is Koeberg, which has two 900MW pressurised water reactors powered by uranium. The Koeberg Power Station uses only locally generated uranium, which is located 30 kilometres north of Cape Town. The facility is owned and run by Eskom, the nation's primary electricity provider.

Table 1-3 below provides a summary of Eskom's electricity supply in 2021. Eskom generated 205 688GWh for the year, from the following primary energy sources:

Table 1-3: Eskom's electricity supply

Source, GWh	2022	2021	2020
Coal-fired stations	184 568	183 553	194 357
Nuclear power	12 355	9 903	13 252
Pumped storage stations	4 743	4 795	5 060
Hydro stations	1 943	1 387	688
Open-cycle gas turbines (OCGTs)	1 826	1 457	1 328
Wind	253	305	283
Eskom generation	205 688	201 400	214 968
Pumping by pumped storage stations	(6 434)	(6 625)	(6 629)
Net sent out by Eskom	199 254	194 775	208 339
Independent power producers	15 973	13 526	11 958
Imports	8 500	8 812	8 568
Wheeling	2 499	2 310	2 491
Energy available for distribution	226 226	219 423	231 356

In 2021, approximately 6 969 153 local consumers received a total of 184 983 GWh of electricity (2021: 178 355 GWh), while 11 overseas customers received 13 298 GWh (2021: 13 497 GWh). In addition, 24 802 GWh (2021: 25 078 GWh) of technical energy losses came from the transmission and distribution process, along with losses from electricity theft and mistakes (ESKOM, 2022). An estimated 1 605 GWh of supply was lost due to load shedding and load curtailment of major customers over the past year, or little over 0.7% of the total energy demand for the year (2021: 1 034 GWh).

The single biggest obstacle to South Africa's economic expansion is load shedding (National Treasury, 2022; Eskom, 2022). Energy that was not supplied in 2021 as a result of load shedding and load reduction for major customers, is anticipated to be 1 605 GWh, or slightly more than 0.7% of the overall energy demand for the year. It is certain that the current course will lead to loadshedding,

either equivalent to or worse than what has been seen in South Africa over the past few years. President Cyril Ramaphosa proposed more changes to address the ongoing electricity crisis of power cuts (load shedding) at the end of July 2022, such as the creation of a National Energy Crisis Committee. Due to capacity limitations brought on by high electricity-generating plant unavailability, load shedding occurred for 65 days during the 2022 financial year (ESKOM, 2022).

According to the CSIR (2022) “in 2022 from January to September, load-shedding occurred for 1 949 hours with an upper limit of 5 761 GWh relative to actual energy shed of 4 315 GWh”. Therefore, the period had:

- The most extensive power outages in history due to intensive load-shedding,
- The majority of the load-shedding has been at Stage 4, marking the first instance where it has not been at Stage 2, and
- Loadshedding occurred for 27% of the hours.

The year 2022 surpassed 2021 as the year with the greatest amount of load-shedding. Additionally, nearly ten times greater than stage 6 load-shedding from 2019. More load-shedding was experienced collectively in the three months from July to September 2022 than in any previous year. In fact, there was more load shedding in September 2022 alone than there was in all of 2020 (CSIR, 2022).

1.8 Infrastructure

According to Burton et al. (2019) one of the issues facing the NDP is the presence of infrastructure constraints, such as inadequate transport connections, limited access to water, and electricity shortages. Just as energy is necessary for economic expansion, so too is a regular water supply, an effective transportation network, and an efficient road system. The South African rail system has endured many years of underinvestment, neglect, crime, and inefficiency (SONA, 2023). In 2022, South Africa implemented the National Rail Policy to direct the modernisation and reform of the rail industry, providing, among other things, for third-party access to the train network, in order to manage the railway crisis (SONA, 2023). To implement policy promises, South Africa is developing a Transnet Roadmap that involves restructuring Transnet Freight Rail to designate a separate Infrastructure Manager for the rail network by October 2023.

At the Durban and Ngqura container terminals, Transnet and private sector businesses will sign partnerships to facilitate fresh investment in the country's ports and boost their effectiveness. This will assist the ports in regaining their reputation as some of the most effective ports worldwide. Repositioning the Port Elizabeth Automotive Terminal, which has more than doubled its capacity and already witnessed an increase in exports, has been an extremely successful project. Vehicles leaving the Port Elizabeth automotive terminal are increasing in number and are headed for overseas markets. Transnet is also growing its fleet and refurbishing its idle locomotives. South Africa has experienced difficulties with commuter train services, but 13 commuter train lines have been restored as a result of the PRASA reform, drastically lowering the cost of transport for many workers (SONA, 2023).

The Department of Water and Sanitation (DWS) is driving the process of funding significant infrastructure projects around the country in order to improve water conditions (SONA, 2023). The Lesotho Highlands Phase Two project which aims to increase the current water transfer rate of 780 million cubic metres per annum incrementally to more than 1 270 million cubic metres per annum, will finally start full-scale construction this year after being postponed for several years. The security of the water supply to Gauteng, the Free State, Mpumalanga, the Northwest, and the Northern Cape depends on the Lesotho Highlands project. The Umzimvubu Water Project's first phase will begin in the following financial year, more than a decade after it was first planned and nine years after a sod-turning ceremony. Government funding will be used to complete this phase, which includes building the Ntabelanga Dam, irrigation infrastructure, and supplying water to communities. The Lilane Dam,

which will have a hydroelectric power plant, will be built at the next stage. Water supply to the West Coast, eThekwini, and the eastern region of Limpopo will be improved by major projects to raise the capacity of the Clanwilliam Dam, Hazelmere Dam, and Tzaneen Dam (SONA, 2023).

For infrastructure project planning, South Africa has allocated R600 million, with a focus on marginalised rural areas (SONA, 2023). Increased public investment in infrastructure is now beginning to result from the support and planning systems in place after several years. A total of R232 billion worth of projects were under construction as of January 2023, and R4 billion worth of projects had already been finished. The projects that have been finished includes the construction of small harbours, new human settlements in Gauteng, and road improvements. A significant event involves the South African National Roads Agency (SANRAL) awarding R18 billion in road construction contracts during the past three months. When completed, the Msikaba and Mtentu bridges will significantly improve transport in the Eastern Cape.

The construction industry will greatly profit from this financial commitment, which will also make it possible to create jobs, improve skills, and alleviate a lot of poverty, especially in the neighbouring rural regions. As part of the Welisizwe plan, the government has committed to build more rural bridges to make it easier and safer for locals to get to schools, places of employment, and service centres. In KwaZulu-Natal, 24 bridges are currently being built, and site preparations are being conducted for an additional 24 bridges. The conclusion of the spectrum auction has also stimulated fresh investment and added R14 billion to the government treasury in the telecommunications sector. The remaining homes in South Africa will switch over to digital television service this year, completing the shutdown of analogue transmission, which will lower the cost of bandwidth while also freeing up precious spectrum for the deployment of 5G mobile networks. These initiatives will help South Africa get closer to realising the goal of universal, low-cost high-speed internet access.

The work of the Infrastructure Fund and Infrastructure South Africa, which was established to fund crucial infrastructure projects, is accelerating the infrastructure building programme. The lack of technical expertise and project management capabilities is one of the biggest barriers to infrastructure investment. To overcome such challenges, initiatives such as Infrastructure South Africa exist, which has a mission to serve as a catalyst for closing the infrastructure investment gap and meeting the infrastructure target set out in the National Development Plan and provides best practises in project preparation, leadership on infrastructure planning, technical and financial support for nationally prioritised infrastructure projects and programmes. The institution has developed an Infrastructure Investment Plan for South Africa, which focuses on Infrastructure Investment Programme for the country, fast-tracking infrastructure implementation, developing credible infrastructure pipelines, and financing the public sector’s infrastructure.

1.9 Water and Sanitation

Freshwater availability in South Africa, which is currently severely constrained, will decline in the future due to declining rainfall and rising evaporation, (Scholes and Engelbrecht, 2021). As the degree of global warming rises, these effects will become even more severe. A warmer, drier southern Africa also sees a decline in water quality, which raises the danger of water-borne illnesses. The GCIS (2022) indicates that South Africa still lacks sufficient water resources and faces difficulties in providing water and sanitation services due to, among other things, inadequate water infrastructure maintenance and investment, recurrent droughts brought on by climatic variation, and unequal access to water and sanitation.

Due to substantial amounts of pressure from mining, intensive agriculture, and urban sprawl, freshwater resources and quality are decreasing (RSA VNR, 2019). At the same time, inadequate maintenance to water-related infrastructure results in leaks and prevents service providers from getting paid for 41% of the water they provide. This not only wastes valuable resources, but also erodes funding for maintaining and enhancing water services due to poor revenue management.

Climate change, which continues to result in changes in temperature, precipitation, and extreme weather, makes the situation more severe (StatsSA, 2023). About 65% of South Africa receives less than 500 mm of rainfall on average per year, and 21% of the country receives less than 200 mm. As a result, the country frequently endures severe and protracted hydrological droughts that can last up to 10 years. Fresh surface water is the principal source of the country's water security, with ground water and return flows being underutilised. There is now 3 551 recognised dams with a 33 291 million m^3 gross storage capacity. Of the registered dams, 4 294 of these are small (less than 12m), supplying communities and agriculture. Local water security and climate resilience are greatly aided by these tiny dams. The entire amount of usable groundwater in the country, on the other hand, is somewhere between 2 and 3 billion m3/a, or roughly 4 500 million m3/a.

Strategic water source locations (catchments with heavy rainfall) are where the majority of freshwater in South Africa is found (StatsSA, 2023). Despite taking up only 8% of the total area, the 22 strategic water source sites contribute 50% of the surface run-off (water entering wetlands, streams, and rivers). The strategic water source areas provide 67% of the nation's economic activity, 60% of the population's water needs, and 70% of the water used for irrigation. Agriculture uses 61% of all water, followed by municipal usage (which includes industrial and commercial customers who receive water from municipal systems) at 27%, and the remaining 12% is made up of electricity generation, mining and bulk industrial use, livestock, conservation, and afforestation.

For the sake of public health and reducing poverty, it is crucial to provide safe and accessible water. The General Household Survey (GHS) of 2021 by Statistics South Africa (StatsSA) shows that between 2002 and 2021, the proportion of households with access to improved supplies of water increased from 84.4% to 88.7%. The Eastern Cape (+14.9 percentage points) and KwaZulu-Natal (+11.6 percentage points) had the largest improvements. Despite these substantial advancements, between 2002 and 2021, access to water decreased in six provinces. The three provinces with the highest declines were Mpumalanga (-4.3 percentage points), North West (-2.2 percentage points), and Limpopo (-4.4 percentage points).

Through the provision and the efforts of government, support agencies and existing stakeholders, the percentage of households with access to improved sanitation increased by 22.4 % points between 2002 and 2021, growing from 61.7% to 84.1%. The two provinces with the greatest improvement were Limpopo (access increased by 31.6% to 58.5%) and the Eastern Cape (access increased by 58.3% to 91.7%). The substantial improvements were largely made possible by the installation of pit toilets with ventilation pipes. A range of reasons, including rapid household growth and urbanisation, as well as a preference for flush toilets have all contributed to the slow progress over the reference period. The relative scarcity of water and regular water interruptions experienced in many parts of the country may increasingly lead to the use of alternative sources of sanitation. Alternative forms of sanitation may become more prevalent due to the country's overall lack of water and frequent water outage.

The GHS (2021) found that families in the Western Cape (99.4%), Gauteng (98.4%), and Free State (93.6%) had tap water inside their homes more frequently than those in Limpopo (69.4%) and the Eastern Cape (71%).

Nationally, the proportion of households with access to improved sanitation increased from 61.7% in 2002 to 84.1% in 2021 (Stats SA's GHS of 2021). The largest percentage of households with access to better sanitation was found in the Western Cape (94.8%), followed by Gauteng (91.8%), the Eastern Cape (91.7%), Limpopo (58.5%) and Mpumalanga (63.2%). Between 2002 and 2021, households' access to better sanitation facilities in the Eastern Cape grew by 58.3 percentage points, going from 33.4% to 91.7%. Nearly two-thirds (64.8%) of houses nationwide used flush toilets that were either connected to a septic or conservancy tank, a public sewerage system, or both, while another 19.3% used pit toilets that are connected to ventilation pipes. Pit toilets without ventilation pipes were primarily used by households lacking access to better sanitary services (13.4%).

The Western Cape (94.8%), Gauteng (87.5%), and Free State (75.2%) were the three provinces with the highest flush toilet usage rates. In Limpopo, about one-fourth (25.6%) of households employed

better sanitation options. The highest percentages of pit toilets with ventilation pipes were found in KwaZulu-Natal (34.0%), Limpopo (32.9%), and the Eastern Cape (43.9%). In Limpopo, 74%of families utilised pit latrines instead of flush toilets, the majority of which (41%) lacked ventilation pipes. Pit toilets without ventilation pipes were utilised by more than one-third (36.7%) of homes in Mpumalanga and 20.5% of households in the Northwest. Household access to improved sanitation was most prevalent in Buffalo City (99.2%) and Nelson Mandela Bay (98.4%) and least prevalent in eThekwini (83.7%) and Tshwane (83.5%)

The DWS developed a Water and Sanitation Sector Policy. The National Climate Change Response (NCCR) White Paper, which addresses all sectors involved in climate change mitigation and adaptation, including the water and sanitation sector, has contributed to the policy's development. Along with health, agriculture, forestry, biodiversity, and human settlements, the NCCR identifies just a few areas as needing immediate attention, which sectors include water and sanitation. The purpose and objectives of the sector policy are:

- To highlight and strengthen the linkages between the NCCR White Paper and water and sanitation sector responses.
- To provide a framework for the implementation of the Climate Change Response Strategy for the water and sanitation sector.
- To strengthen the development, implementation and enforcement of regulations that has implications for climate change.
- To highlight the policy principles of the water and sanitation sector with regards to climate change.

To strengthen the effective preservation, conservation, and management of water resources against the effects of climate change, the Water and Sanitation Sector Policy on Climate Change lays forth a number of guiding principles. The sector policy modified the White Paper's guiding principles by adding principles from the Second National Water Resource Strategy (NWRS2), as well as the NDP and the National Water Resource Strategy. It also took into consideration the Climate Change Strategy for the Water Sector for the SADC region.

Following the SADC framework, the policy has defined three categories of strategic activities to ensure adaptation to climate change: water and sanitation governance, infrastructure development, and water and sanitation management.

The sector has adopted the following key elements to achieve mitigation:

- Identify desired sectorial mitigation contributions.
- Develop a sector mitigation plan.
- Develop, contribute, and implement a wide range and mix of different types of mitigation approaches, strategies, measures, and actions that optimise the mitigation outcomes for the sector.
- Contributing to a national system of data collection for the sector to support the proposed Climate Change Response Monitoring and Evaluation System.

1.10 Agriculture, Forestry and Fisheries

1.10.1 Agriculture

Agriculture makes a substantial contribution to household food security and is crucial to the process of economic growth (GCIS, 2022). In the last two years, the agriculture industry has grown strongly,

increasing by 8.3% in 2021 and 13.4% in 2020. About 868 000 people were employed in the sector in the fourth quarter of 2021, demonstrating steadiness over the previous few years.

Figure 1-19 below shows that only 17.2% of South African households were involved in some sort of agricultural production activities during the reference period. Households in Limpopo (37.9%), Eastern Cape (33.4%) and Mpumalanga (32.2%) were most involved, while only 2.9% of households in Western Cape, and 6.4% of households in Gauteng engaged in some agricultural activity. (StatsSA, 2021).

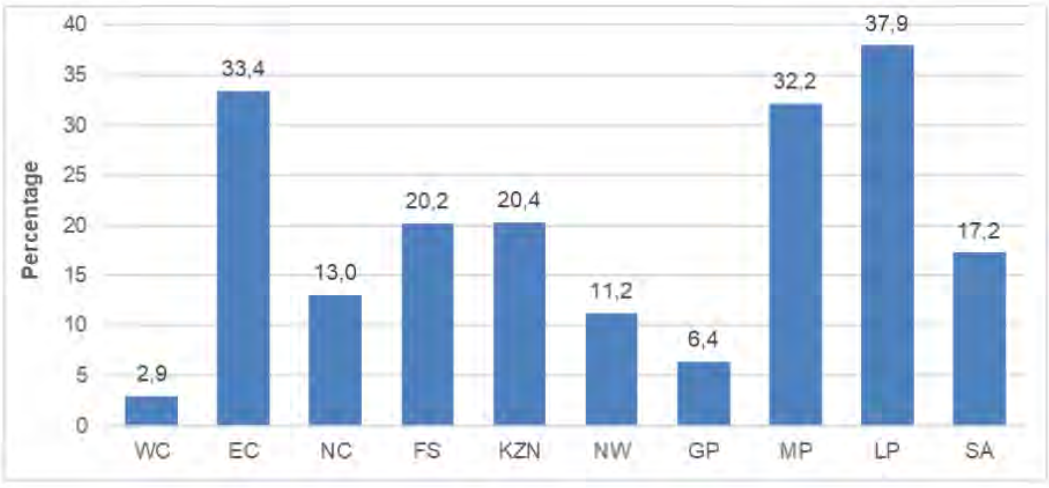

Figure 1-19: Percentage of households involved in agricultural activities by province, 2021

More than four-fifths (85.0%) of South African households that were involved in agriculture were involved in an attempt to secure an additional source of food. Another 4% of households engaged in agriculture as a subsistence activity (producing the main source of food), while 5% used agriculture to produce additional income.

The Department of Agriculture Land Reform and Rural Development's (DALRRD) 2021/22 annual report revealed two prominent challenges experienced in South Africa's agricultural sector, with the first being the devastatingly widespread uprisings in KwaZulu-Natal (KZN) and Gauteng (GP) during 2021/22, which had a negative impact on the sector. This occurred shortly after tropical cyclone Eloise, which impacted many provinces, including Northwest (NW), Mpumalanga (MP), Limpopo (LP), the Free State (FS), some parts of KZN, and the Eastern Cape (EC), which has left the sector still recovering from its consequences. The second most prominent challenge was found in three provinces, the Eastern Cape (EC), Northern Cape (NC), and Western Cape (WC) which experienced brown locust outbreaks. The reason for the outbreak was due to the amount of rain that these provinces received, causing the development of a new generation after the other. As the Karoo and surrounding areas experienced constant rain, the locust infestation reached its greatest level in decades. The swarms were also moved by the wind to places where they had never previously dispersed, such as the Garden Route region in WC and to citrus farmers in Kirkwood and Patensie in EC, as well as certain communities in the EC province.

The DALRRD and the Department of Health (DoH) have committed to improve the environment for hemp and cannabis growth so that traditional farmers' harvests can be collected and grown outdoors (SONA, 2023). This will unleash a significant amount of economic vitality in the nation's rural areas, particularly in the Eastern Cape, KwaZulu-Natal, and Mpumalanga. Government officials are urgently working to complete the development of an enabling regulatory framework for a whole plant (for hemp and cannabis production), all legitimate purposes approach to dietary supplements, foods, cosmetics, and industrial products that is in accordance with global norms and best practises. This entails reallocating government budgets to promote traditional, black farmers and sector growth, as well as aligning South African Police Service (SAPS) enforcement with regulatory reforms.

In order to alleviate social injustice and inequality through expedited land reform, the DALRRD sought to acquire 130 687 hectares of productive land for land reform objectives at an estimated cost of R3 billion over the long term (GCIS, 2022). The department has established a hybrid finance strategy with grant and loan components to pay for this. A boost to food security and agricultural reform has been provided by the distribution of input vouchers to around 140 000 small-scale farmers for the purchase of seeds, fertiliser, and equipment (SONA, 2022). About 640 000 hectares of land have been put under cultivation as a result of this programme. Impressively, 68% of these farmers are female.

1.10.2 Forestry

The contribution of the forest sector (forestry and forest products) to the GDP of South Africa in 2021/22 is approximately 0.6%, a significant decrease from the 1.2% average contribution seen during the previous years (GCIS, 2022). Forestry products are one of the top five manufacturing industries in South Africa, contributing at least 4.5% to overall manufacturing. Forestry makes up 2.7% of KwaZulu-Natal's regional GDP, 3.0% of Mpumalanga's, 0.7% of the Eastern Cape's, 0.5% of Limpopo's, and 0.2% of the Western Cape's.

Over 38 million hectares (ha) or 31.1% of South Africa’s land surface is covered by forest resources, and in 2021/22 the economy benefitted in the amount of R36.34 billion from forest products. Export revenue dropped from R26 to R24.7 billion, a 5% decline. A 1.2 million ha well-developed forest plantation serves as the foundation for this, and the sector has created 147 400 direct jobs in the forestry industry. Additionally, it showed that export revenues had practically tripled, resulting in a favourable trade balance of up to R10 billion in less than ten years.

Forestry operations are largely based in rural areas, making it a major contributor to rural economies and social welfare. Around 648 000 people in the rural areas of South Africa rely on forestry for their livelihood. About 16 000 direct and 10 000 indirect jobs are offered by the pulp and paper industry. Around 18 100 direct workers and 6 000 indirect workers are employed in the sawmilling, 3 600 in the timber board, and 2 000 in the mining of timber industries, while an additional 7 500 people work in forestry-related activities of all kinds.

1.10.3 Fisheries

According to GCIS (2022), the fishing industry makes for approximately 0.1% of the GDP. In the Western Cape, where 11 of the 13 authorised fishing harbours are located, this industry is particularly crucial for economic growth. These harbours boost the provincial GDP by more than 5%. Depending on the pelagic capture of pilchards and anchovies, which may reach 600 000 t, the overall output is anticipated to be 600 000 t, or roughly R6 billion.

The fishing industry in South Africa continues to make a substantial contribution to both economic growth and food security. To attract investment into the sector, it is essential to stabilise the sector by distributing longer-term fishing rights. Around 28 000 people are employed directly in the commercial fisheries industry, which has an annual revenue of about R8 billion. Many thousands more rely on fisheries resources to meet their basic needs in the small-scale and recreational sectors.

More than 3000 kilometres of our country's coastline connect Africa's east and west coasts. These are biodiverse coastlines, with over 10 000 known marine plant and animal species. South Africa is one of the fishing countries in the world that has recognised the issues facing its own fishing sector. The country has two fisheries sector components, with 22 commercial fisheries sectors and new fisheries being explored and experimented with. First, the wild capture fisheries include three distinct components, namely commercial, recreational, and subsistence fisheries, each of which requires specific research and management interventions. Second, the aquaculture (fish farming) sub-sector is considered underdeveloped and as a result, has been prioritised due to declining wild fish populations. Hake, anchovies, sardines, horse mackerel, tuna, snoek, rock lobster, and abalone are just a few of the commercially exploited marine species that may be found in the West Coast's rich ocean. Squid,

line fish, and a variety of intertidal resources are key sources of food and income for coastal communities along the east coast.

In comparison to the case where there is no climate change, there is a substantial possibility that agricultural production in southern Africa, particularly that of cattle and staple crops, will decrease. This is because most crops and animals cannot be produced in the region at present temperatures, which also results in crop and pasture output declines in a country that is already dry. As global warming progresses, these effects will worsen, and at 3 °C of warming, the collapse of crucial crops and the animal industry is likely (Scholes and Engelbrecht, 2021).

1.11 Institutional Arrangements for Climate Change in the Country

According to GCIS (2022), South Africa is a constitutional democracy with a three-tiered government system and an independent judiciary. The Constitution of the Republic of South Africa, 1996 defines the national, provincial, and local levels of government as distinct, interconnected, and interrelated entities that each have legislative and executive responsibility over matters within their respective jurisdictions. Advisory groups, made up of South Africa's traditional leaders, operate on both the national and provincial levels. The Constitution makes it clear that a system of cooperative governance would be used to rule the nation. In combating climate change, all three branches of government have significant tasks to play (DFFE, 2021). When it comes to generating revenue and developing bylaws that follow the Constitution and policies, the local governments have a more autonomous role. A clear framework for mainstreaming climate change planning and action throughout the many realms of government is provided by the National Climate Change Response Policy (NCCRP) (implemented by DEA, 2011, now referred to as DFFE).

According to the Climate Action Tracker (CAT) (2022), although there are several important areas that still require development, South Africa's institutional architecture for climate mitigation is strengthening. Although vertical and horizontal coordination institutions are in place and there has been some mainstreaming of climate policies, sectoral policy planning and overarching national goals can be more closely integrated. The climate change lead agency has designed and executed climate policy effectively, despite having a smaller budget and scarce human resources. Additionally, the CAT (2022) states that South Africa's political culture has made considerable use of collaborative policymaking. To reach a larger portion of the population and boost public support for the shift to a society that emits no emissions, government initiatives that inform the public about the climate crisis could be scaled up. Despite the availability and extent of climate change content, non-state actors from every viewpoint have been successful in advancing their own goals. While there are indications that recent developments, such as the rising cost-competitiveness of renewables, may align interest with a transition by expediting the decarbonization of the electricity sector, large companies are still exerting their influence.

The fact that many government agencies and municipalities have begun mainstreaming climate change into their government strategies, policies, and Integrated Development Plans (IDPs) (DFFE, 2021), shows that South Africa is ready to combat climate change while providing services to its citizens.

Section 6 of the Climate Change Bill (2022) states that **"***in the event of any conflict between a provision of this Act and other legislation specifically relating to climate change, this Act prevails".* The Bill further outlines the institutional arrangement and roles for climate change oversight, as shown in Table 1-4 below:

Table 1-4: Description and roles for government institutions

Institution	Description of role
Provincial Forums on Climate Change (Section 8)	1) Every Premier's intergovernmental forum, established in terms of section 16 of the Intergovernmental Relations Framework Act, also serves as a Provincial Forum on Climate Change. 2) Sections 17 and 19 of the Intergovernmental Relations Framework Act apply to a Provincial Forum on Climate Change. 3) A Provincial Forum on Climate Change must— i. coordinate climate change response actions in the relevant province in accordance with this Act; and ii. provide a report to the President's Coordinating Council in terms of section 20(a) of the Intergovernmental Relations Framework Act, which report must include climate change considerations. 4) A Provincial Forum on Climate Change may establish an intergovernmental technical support structure in terms of section 30 of the Intergovernmental Relations Framework Act if there is a need for formal technical support to the Provincial Forum on Climate Change.
Municipal Forums on Climate Change (Section 9)	1) Every district intergovernmental forum, established in terms of section 24 of the Intergovernmental Relations Framework Act, also serves as a Municipal Forum on Climate Change. 2) Sections 25 and 27 of the Intergovernmental Relations Framework Act apply to a Municipal Forum on Climate Change. 3) A Municipal Forum on Climate Change must— i. coordinate climate change response actions for those activities within its operational control of the relevant municipality in accordance with this Act; and ii. provide a report on such actions to the relevant Provincial Forum on Climate Change. 4) A Municipal Forum on Climate Change may establish an intergovernmental technical support structure in terms of section 30 of the Intergovernmental Relations Framework Act if there is a need for formal technical support to the Municipal Forum on Climate Change.
Presidential Climate Commission	11. The functions of the Presidential Climate Commission are to— a. advise on the Republic's climate change response to ensure the realisation of the vision for effective climate change response and the long-term just transition to a low-carbon and climate-resilient-economy and society; b. advise government on the mitigation of climate change impacts, including through the reduction of emissions of greenhouse gases, and adapting to the effects of climate change; and b) (c) provide monitoring and evaluation of progress towards government's emissions reduction and adaptation goals.

Furthermore, the Bill mentions the following National Departments for:

a) Functions relevant to the development of Sectoral Emissions Targets

- Agriculture;
- Cooperative Governance;
- Economic Development;
- Energy;
- Environment;
- Fisheries;
- Forestry;
- Health;

- Human Settlements;
- Industry;
- International Relations;
- Land Reform;
- Mineral Resources;
- National Treasury;
- Public Enterprises;
- Public Works;
- Rural Development;
- Sanitation.
- Science;
- Technology;
- Trade;
- Traditional Affairs;
- Transport; and
- Water Affairs.

b) National Departments and State-Owned Entities responsible for certain functions required to develop a Sector Adaptation Strategy and Plan

- Agriculture;
- Disaster Risk Reduction;
- Energy;
- Environment;
- Fisheries;
- Forestry;
- Health;
- Human Settlements;
- Land Reform;
- Manufacturing;
- Public Enterprises;
- Rural Development;
- Sanitation.
- Science;
- Technology;
- Transport; and
- Water Affairs.

c) Provincial and Local Government institutional arrangements

In partnership with their respective environmental departments, provincial organisations are given the responsibility of leading climate change response efforts at the provincial level (Figure 1-20). To give provincial stakeholders a forum to learn about climate change and coordinate their own climate change responses, most of the lead ministries have developed provincial climate change frameworks.

The South African Local Government Association (SALGA) has the responsibility of assisting, representing, and advising local governments on matters involving local governance, which is the branch of government closest to the people, thus playing a crucial role in the country. Municipalities thus organise the delivery of services within their own communities.

The level of local government is the most suitable for raising public awareness and helping localities establish resilient environments that are better and more sustainable. The Department of Forestry, Fisheries and the Environment (DFFE) and SALGA advise District and Local Municipalities in

conducting Climate Vulnerability Assessments and integrating climate action into their respective policies, strategies, and plans.

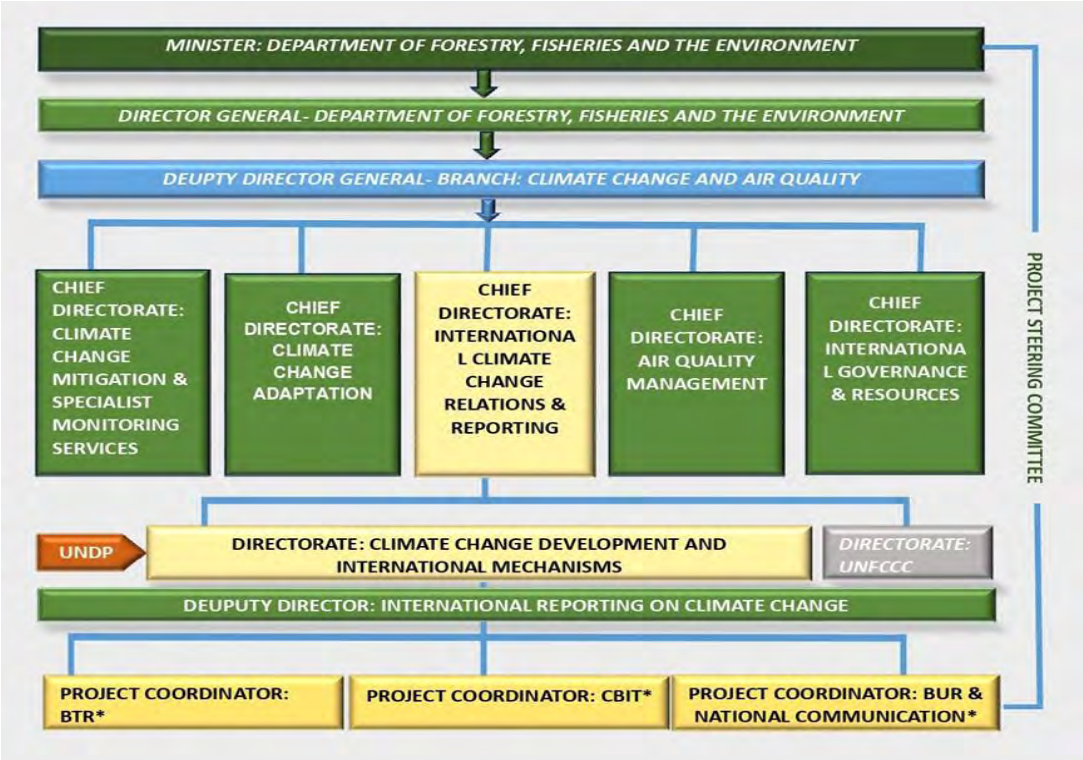

Figure 1-20: Institutional Arrangements for the Preparation of the NC4

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2 National Greenhouse Gas Inventory

This chapter presents a summary of South Africa's 8th National Greenhouse Gas (GHG) Inventory, covering the period 2000 to 2020. The inventory is compiled in accordance with the 2006 IPCC Guidelines for National GHG Inventories, the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol, and the 2019 Refinement to the 2006 IPCC Guidelines (IPCC, 2006, 2014, 2019). The national inventory includes both sources of GHG emissions and removals by sinks covering four sectors: Energy; Industrial Process and Product Use (IPPU); Agriculture, Forestry and Other Land Use (AFOLU); and Waste.

Sections 2.1, 2.2 and 2.3 describe the evolution of South Africa's GHG Inventory, provide an overview of the institutional arrangements as well as information on methodologies, activity data and emissions factors. A summary of South Africa's 2000 to 2020 GHG emissions trends by gas and sector are presented in Section 2.4 along with the Key Category Analysis. The GHGs reported on include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs). Indirect greenhouse gases (i.e., carbon monoxide, nitrous oxides and non-methane volatile organic compounds) are included for biomass burning only. Sulphur hexafluoride (SF_6) emissions are not included due to a lack of data. Section 2.8 provides details on the GHG Improvement Programme (GHGIP).

2.1 Evolution of South Africa's GHG Inventory

South Africa, along with the majority of the international community, ratified the UNFCCC in 1997. As part of its reporting obligations, South Africa's first national GHG inventory was prepared in 1998, using 1990 data. In 2004 it was updated to include 1994 data, using the 1996 IPPC Guidelines for National Greenhouse Gas Inventories. In 2009, the 2000 national inventory was compiled using the 2006 IPCC Guidelines. Following these guidelines, in 2014, the national GHG inventory was compiled for the years 2000 to 2010. An update was completed for 2011 and 2012 in 2016, for 2013 to 2015 in 2018 and 2017 in 2021. In 2023, the most recent GHG Inventory was published for the years 2000 to 2020. Figure 2-1 shows the evolution of South Africa's national inventory over the years.

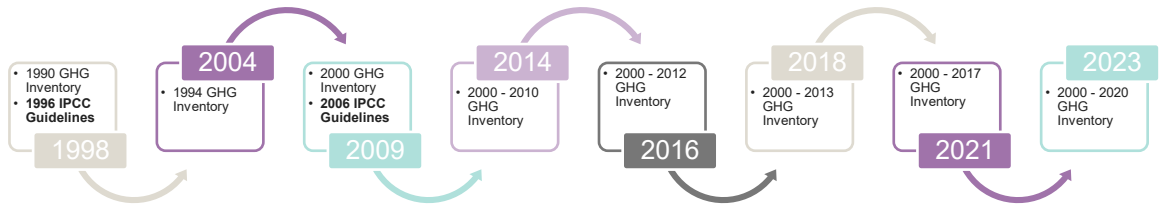

Figure 2-1: Evolution of submitted GHG inventories over the years

2.2 Institutional Arrangements

The Department of Forestry, Fisheries and the Environment (DFFE) is responsible for the compilation, implementation and reporting of the national GHG Inventories. Figure 2-2 gives an overview of the institutional arrangements within DFFE for the compilation of the 2000 to 2020 GHG emissions inventory. DFFE is supported by other relevant agencies and ministries who assist with data provision across the relevant sectors. Data used in the inventory is sourced from a number of institutions, associations, companies and ministerial branches.

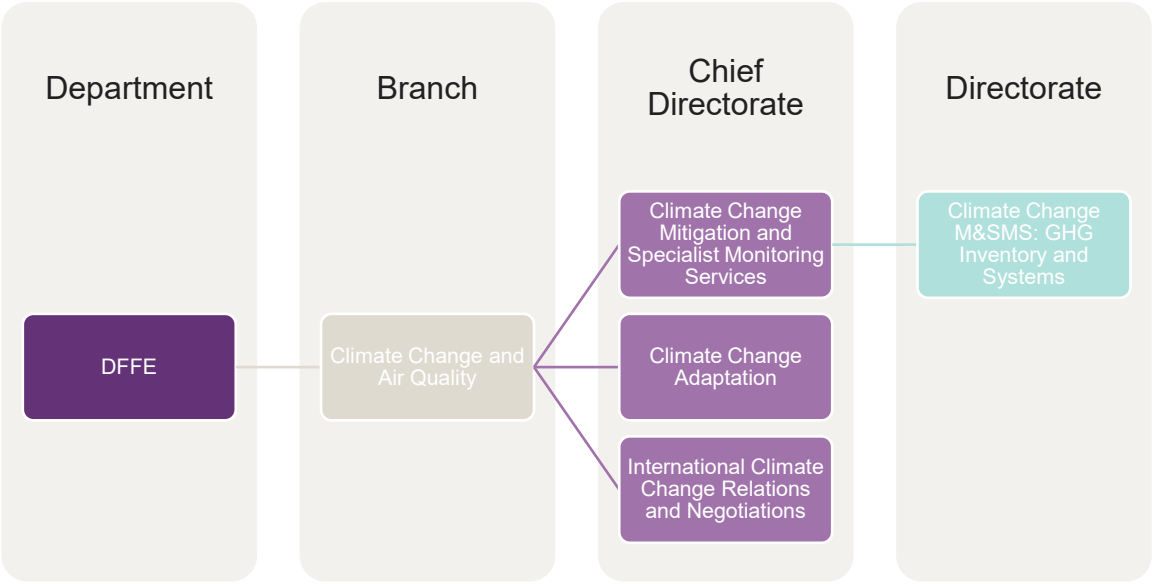

Figure 2-2: Institutional arrangements for the compilation of the 2000 to 2020 inventory for South Africa

In 2017, the National Greenhouse Gas Emissions Reporting Regulations (NGERS) were published by government to aid in the collection of data from the energy sector and industries (including plantation industries and certain agricultural industries). The aim of the NGERs is to introduce a single reporting system for transparent reporting of GHG emissions and energy production and use. This information is then used to update and maintain the national GHG inventory and support reporting obligations under the UNFCCC. As part of this, the South African Greenhouse Gas Emissions Reporting System (SAGERS)[2] was established as a tool for industry to fulfil its mandatory GHG reporting.

2.3 Methodology

The 2006 IPCC Guidelines and 2019 Refinements were used in the preparation of the inventory (IPCC, 2006, 2019). The methods for estimating emissions and removals are divided into three tiers and the choice of method is dependent on the availability of data as well as the importance of the source category. A description of the three tiers is provided below:

- Tier 1: Apply IPPC default emission factors and use IPCC default models.
- Tier 2: Apply country-specific emission factors and use IPCC default models.
- Tier 3: Apply country-specific emission factors and use country-specific models.

Table 2-1 provides a summary of the methodologies used in each sector. The majority of sectors and sub-sectors use Tier 1 methodology and apply IPCC default emission factors. Selected sub-sectors use Tier 2 and Tier 3 methodologies and country-specific emission factors, where possible. Emissions in the Energy sector are estimated using a sectoral approach, with mix of Tier 1, Tier 2 and Tier 3 methods. The IPPU sector also uses a combination of Tier 1, Tier 2 and Tier 3 methods. The AFOLU sector uses Tier 1 and Tier 2 methodologies, with a mix of both default and country-specific emission factors. The IPCC 2006 methodology, with updated methodologies from the IPCC 2019 Refinement and 2013 Wetlands Supplement have been applied to this sector. The Waste sector uses the Tier 1

[2] The South African Greenhouse Gas Emissions Reporting System (SAGERS) is a Greenhouse Gas Reporting Module of the National Emissions Inventory System (NAEIS). SAGERS is an online platform for the submission of GHG emissions data per IPCC category.

method for all emissions estimates, with solid waste calculated using the IPCC first order decay model.

Table 2-1: Methodologies and emission factors used per sector[3]

Sector	Method	Emission factors
Energy	Mostly Tier 1 & Tier 2 (T3 for selected sub-sectors)	Mostly default emission factors Country-specific emission factors for: - Sub-bituminous coal (CO_2)[4] - Railways - Coal mining and handling
IPPU	Mostly Tier 1 (T2/T3 for selected sub-sectors)	Mostly default emission factors Country-specific/Tier 3 approach for: - Glass - Selected chemicals - PFCs in aluminium production
AFOLU	Tier 1 and Tier 2	IPCC default Tier 1 and Tier 2
Waste	Tier 1	IPCC 2006 default emissions factor Country-specific: - CH_4 Wastewater treatment and discharge

To comply with international reporting obligations under the UNFCCC, the South African GHG Inventory presents emissions for each greenhouse as CO_2e (carbon dioxide equivalent) using 100-year global warming potentials (GWPs) sourced from the IPCC Second Assessment Report (SAR) (IPCC, 1995).

The main sources of activity data per sector are summarised in Figure 2-3. SAGERs is a key source of company data for the Energy and IPPU sectors. Other key data sources for these sectors include government departments such as the Department of Mineral Resources and Energy (DMRE) and Department of Transport (DoT), industry associations and relevant companies. AFOLU and Waste activity data was sourced from relevant government departments, research institutions and industry associations.

[3] Technical Guidelines for Monitoring Reporting and Verification of GHG Emissions Industry (DEA, 2017)

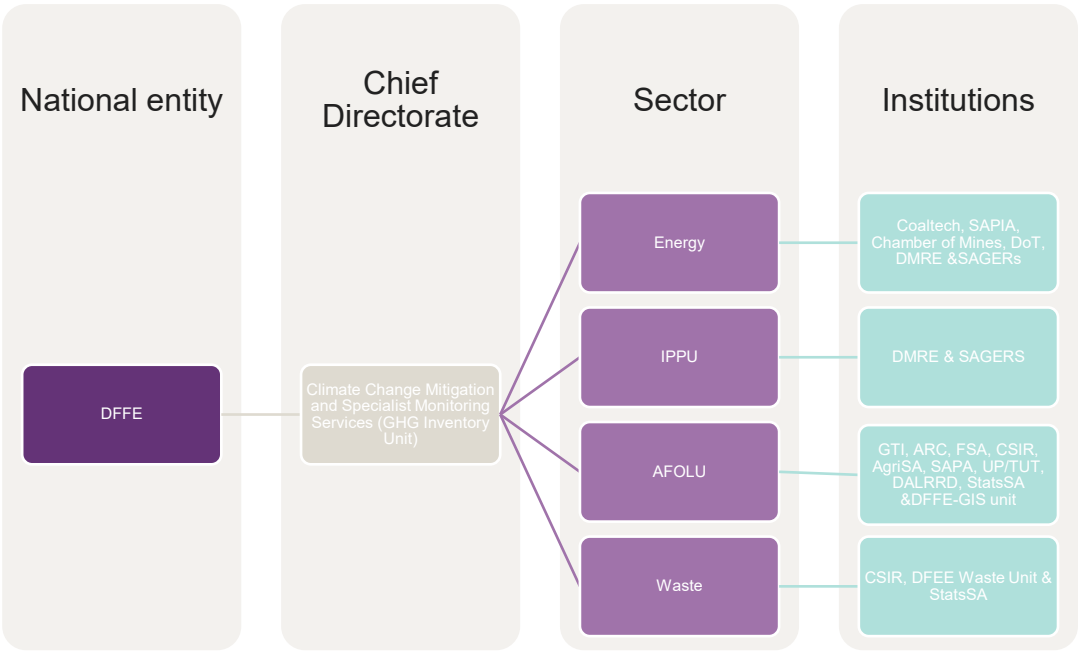

Figure 2-3: Sources of activity data per sector

2.3.1 Improvements and Recalculations

Since the previous inventory, improvements have been made to the National GHG Inventory through the inclusion of more detailed activity data and updated emission factors. Table 2-2 provides an overview of improvements introduced in the current inventory.

Table 2-2: Improvements introduced in the current inventory.

Sector	Improvements
Energy	Updated consumption data: - Road transport - Manufacturing industries and construction - Other sectors - Non-specified emissions from energy production Updated coal statistics
IPPU	Additions to the inventory: - Other process uses of carbonates - Dolomitic lime at to Lime production - Silicon carbide production - Soda ash production - Hydrogen production - Other chemical processes Error corrected in Titanium dioxide production category. Change in activity from primary production to treatment of secondary raw material under Lead production

Sector	Improvements
AFOLU	Livestock - Tier 2 data for enteric fermentation and manure management emissions calculations for cattle, goats and sheep is used. - Changes in the livestock categorisation - Update of manure management data Land - Updates made to include the 1990 – 2018 land change matrix. - Inclusion of: o Updated biomass and DOM data; o New biomass conversion and expansion factor for plantations; o Country-specific Soil Organic Carbon reference and stock data change; o Mortality; o charcoal production; and o CO_2, CH_4 and N_2O from mineral inland wetlands. Aggregated and non-CO_2 sources on land - Improvements due to updated livestock data - Burnt area data updated to MODIS Collection 6. Other - Country-specific data included for HWP
Waste	Updated: - Waste generation rate per person - Waste generation rate per GDP - Fractions of municipal solid waste and industrial waste sent to Solid Waste Disposal Sites

The improvements resulted in higher reported emissions than previous estimates in the period 2000 to 2013, after which estimates were lower than previous estimates. Recalculated 2017 emissions based on improvements resulted in a 2.8% and 0.5% decrease in emission estimates excluding and including FOLU, respectively. The highest change in recalculated emissions, for 2017, was a 32.8% increase in the LULUCF sector and a 12.7% decrease in emissions for the AFOLU sector. Recalculations resulted in a 2.1% decrease in emissions for the Energy sector, 2.1% increase for Waste sector and 0.5% increase in IPPU emissions for 2017.

Table 2-3: Recalculations per sector

Sector	2017
Energy	-2.1%
IPPU	0.5%
FOLU	32.8 %
Agriculture	-12.7%
Waste	2.1%
Total incl. FOLU	-0.5%
Total excl. FOLU	-2.8%

In the Energy sector, recalculations resulted in a 2.1% decrease in the current inventory for the year 2017 and 4.4% to 8.5% higher than previous estimates between 2000 and 2009. In 2014 and 2015 the estimates are 1.8% and 0.9% lower. Recalculations in the IPPU sector was relatively minor, resulting in a 0.5% increase in emissions in the current inventory for the year 2017. Recalculations within the sector were mostly limited to the lead production sector. In the Waste sector recalculations resulted in a 2.1% increase for the year 2017 in the current inventory.

Recalculations in the AFOLU sector led to the most significant changes, with an average 15.7% decrease in estimates excluding FOLU and an average of 7.5% decrease (this varied annually) in emissions including FOLU over the time series. The recalculations led to a 25.1% increase in 2017 estimates for Livestock and a 57% decrease in 2017 emissions estimates for Aggregated and non-CO_2 emissions on land. The Land category showed a 39.8% decline in the 2017 sink estimate due to a correction in the burnt area data for 2017. Between 2011 and 2016 the recalculated emission values were, on average, 22.8% higher than was estimated in the previous inventory. Recalculations for HWP due to the inclusion of country-specific data produced a 24.2% decline in the 2017 estimates, but this varied annually.

2.3.2 Key Category Analysis Methodology

A key category (which includes both source and sink categories) is a category that is prioritised within the national inventory system because its estimate has a significant influence on the total GHG's in terms of the absolute level, the trend or uncertainty in emissions and removals (DFFE, 2022). The key category analysis (KCA) allows resources to be allocated to appropriate activities in order to improve those specific categories in future submissions.

There are two approaches that can be used to determine the key categories (DFFE, 2022):

- Level approach: used if only one year of data is available and determines the contribution from the categories to the total national inventory.
- Trend approach: used if there are two comparable years of data. This approach identifies categories that may not be large enough to be identified by the level assessment, but whose trend is significantly different from the trend of the overall inventory and thus should receive attention.

South Africa's National GHG Inventory conducted both Approach 1 level (L1) and Approach 1 trend (T1) methodologies from the 2006 IPCC Guidelines, applied to both emissions including and excluding FOLU. Subsequently, the key categories are ranked according to their combined contribution to the level and trend assessments, with the top-ranking category receiving a score of 1 and the second a score of 2 etc. The overall scores from both approaches are combined to give an overall score for each category and ranked from lowest to highest (ranking approach only applied to assessments including FOLU).

The KCA identifies key categories whose emissions and removals sum to 95% of the gross or net level of emissions and those within the top 95% of categories that contribute to the change between 2000 and 2020, or the trend of emissions. The level assessment was conducted using the base year 2000 and current year 2020. The trend assessment utilised the base year 2000 and 2020. The KCA for the GHG Inventory 2000 to 2020 is discussed in detail in Section 2.7 and describes changes from the previous inventory.

2.3.3 Uncertainty Assessment

The uncertainty analysis of information is a critical element of a complete and transparent inventory. South Africa applied a Tier 1 methodology for determining uncertainty. The inventory currently uses

numerous IPCC default uncertainties, however as data becomes available on country-specific uncertainties these values will be improved and South Africa will move to a Tier 2 approach.

In general, emission estimate uncertainties are typically low for CO_2 from energy consumption and some industrial process emissions and higher for AFOLU and synthetic gases. Uncertainty ranges for various sectors are largely consistent with typical uncertainty ranges expected for each sector.

A trend uncertainty (determined using Approach 1) between the base year and 2020, as well as combined uncertainty of activity data and emissions factor uncertainty was determined. The total uncertainty for the inventory was between 8.13% and 8.77% (including FOLU), with a trend uncertainty of 6.71%. Excluding FOLU reduced the overall uncertainty to between 6.64% and 7.32%, with the trend uncertainty dropping to 6.21%.

2.3.4 Quality Control and Assurance

Following IPCC requirements, the national GHG Inventory includes quality control and quality assurance (QC/QA) procedures. Quality checking improves transparency, consistency, comparability, completeness, and accuracy of the national inventory. QC procedures are performed at various stage throughout the inventory compilation process and are completed at 4 different levels:

- Inventory data (activity data, emission factors, uncertainty, and recalculations).
- Database (data transcriptions and aggregations).
- Metadata (documents of data, experts and supporting data).
- Inventory report.

South Africa has developed a formal quality assurance/quality control plan, as part of the NGHGIS. This provides a list of QC procedures to be undertaken during the preparation of the inventory. General QC checks, category-specific QC checks as well as technical reviews of source categories, activity data, emission factors and methods are applied. QC procedures are focused on key categories and on categories where substantial methodological and data revisions have taken place.

The QA process was completed through a public review process and the inventory was reviewed by the UNFCCC through an in-country QA workshop provided by the GHG support unit. The inventory was finalised once comments from the QA process were addressed.

2.4 Overview of the 2000 to 2020 National GHG Inventory

South Africa's GHG emissions for 2020 totalled 468 812 $GgCO_2e$, excluding FOLU. The contribution of emissions from forestry and other land use (FOLU) results in net emissions of 442 125 $GgCO_2e$. This is because the Land sector is a sink, with the Forest Land sub-sector contributing the most to the carbon sink. Table 2-4 presents South Africa's National GHG Inventory disaggregated by sector between 2000 and 2020. Key trends include:

- The energy sector accounts for 86% of total emissions (including FOLU) in 2020, an increase from 83% in 2000.
- Overall, the energy sector showed a 2.2% increase in emissions from 2000 to 2020.
- GHG emissions from the IPPU and AFOLU (including FOLU) decreased by 23% and 40% from 2000 to 2020 respectively.
- The waste sector saw an increase in emissions of 26% from 2000 to 2020.
- Overall, net GHG emissions in South Africa have decreased by 0.84% since 2000, from 445 885 $GgCO_2e$ to 442 125 $GgCO_2e$.

- GHG emissions (including FOLU) rose steadily reaching a peak in 2009 (552 758 $GgCO_2e$), before decreasing from 2009 to 2020. This can be attributed to several factors including a deteriorating economy, coupled with the impact of COVID-19.

Table 2-4: Trends and levels in net GHG emissions (including FOLU) per sector between 2000 and 2020 ($GgCO_2e$)

Year	Energy	IPPU	AOLU excl. FOLU	AFOLU incl. FOLU	Waste	TOTAL
2000	371 345	32 955	42 439	23 344	18 241	445 885
2001	374 140	33 221	43 316	33 223	18 344	458 927
2002	384 309	35 204	43 373	35 548	18 566	473 627
2003	405 171	34 507	42 358	25 454	18 803	483 934
2004	419 522	34 617	42 104	34 632	18 859	507 629
2005	411 995	37 826	43 110	53 010	19 086	521 917
2006	407 033	38 900	42 973	50 443	19 296	515 672
2007	434 435	37 239	43 825	47 421	19 502	538 597
2008	432 848	35 441	44 365	58 959	19 742	546 991
2009	461 135	33 612	44 067	38 277	19 732	552 758
2010	426 505	35 928	43 755	44 547	20 007	526 987
2011	420 764	39 510	43 672	37 506	20 114	517 895
2012	432 091	38 654	44 741	38 435	20 307	529 487
2013	432 563	38 213	43 877	28 496	20 491	519 764
2014	409 533	39 097	44 587	34 420	20 660	503 710
2015	410 241	41 402	42 925	23 431	20 896	495 970
2016	409 457	40 121	41 963	8 666	21 123	479 366
2017	401 901	32 261	42 488	23 905	21 699	479 767
2018	413 151	30 105	41 802	25 206	21 989	490 451
2019	407 383	27 041	40 931	19 275	22 299	475 998
2020	379 505	25 486	40 775	14 088	23 046	442 125
Percentage change 2000 - 2020	**2,2%**	**-22.7%**	**-3.9%**	**-39.7%**	**26.3%**	**-0.84%**

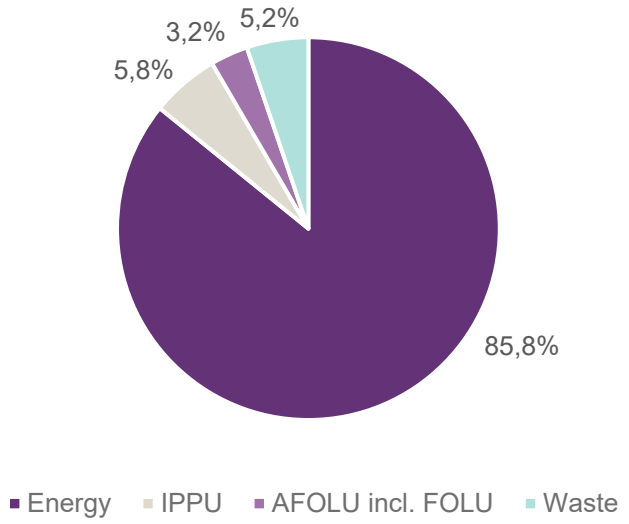

Figure 2-4: South Africa's 2020 National GHG Inventory (net emissions), disaggregated by sector

2.5 GHG Emission Trends and Time-series

South Africa's National GHG Inventory time series from 2000 to 2020 is presented in Figure 2-5. It shows a steady increase in emissions to 2009 before declining to 2020. The largest decrease in emissions was recorded between 2019 and 2020 (7.12%), largely attributed to COVID-19 and its impact on the economy. Total net emissions trends showed a marginal decrease of 0.84% over the period, decreasing from 445 885 $GgCO_2e$ in 2000 to 442 125 $GgCO_2e$ in 2020.

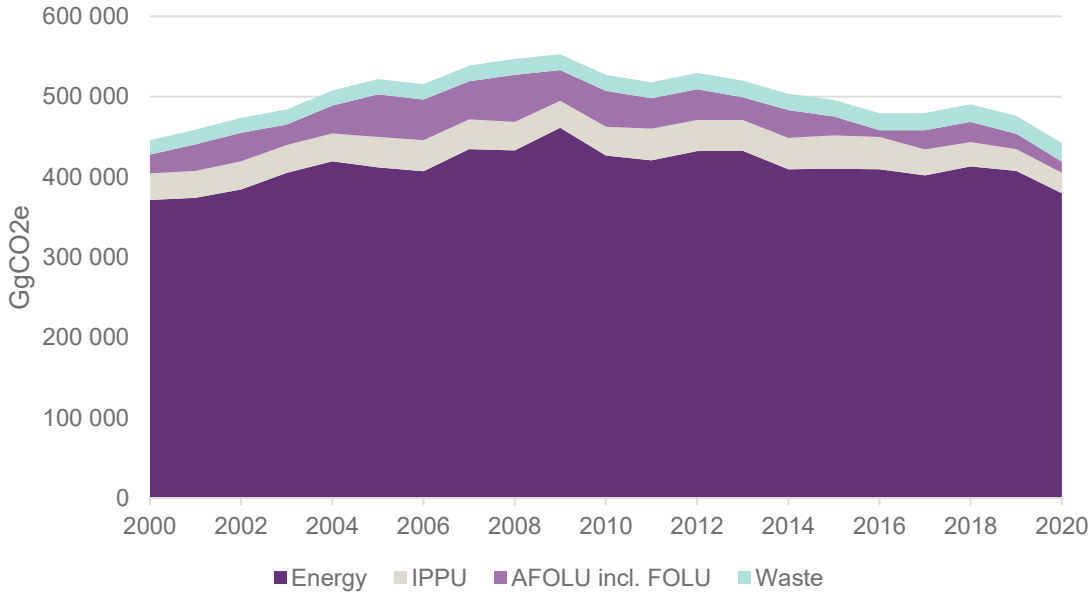

Figure 2-5: South Africa's net GHG inventory time-series 2000 - 2020, disaggregated by sector

Figure 2-6 shows the distribution of emissions per sector (for both gross and net emissions).

The energy sector contributed 81% of the total gross GHG inventory (excluding FOLU emission) in 2020, an increase from 79.9% in 2000.

The AFOLU sector (excluding FOLU emissions) is the second largest contributor to emissions accounting for 9.1% of emissions in 2000, decreasing to 8.7% of the gross emissions in 2020.

The IPPU has seen a decline in its contribution to total gross emissions from 7.1% in 2000 to 5.4% in 2020, particularly from 2015.

The Waste sector has seen a steady increase in its contribution from 3.9% in 2000 to 4.9% in 2020.

The inclusion of the FOLU component results in changes in the contribution from the Energy, IPPU, AFOLU and Waste sectors to 85.8%, 5.8%, 3.2% and 5.2% respectively.

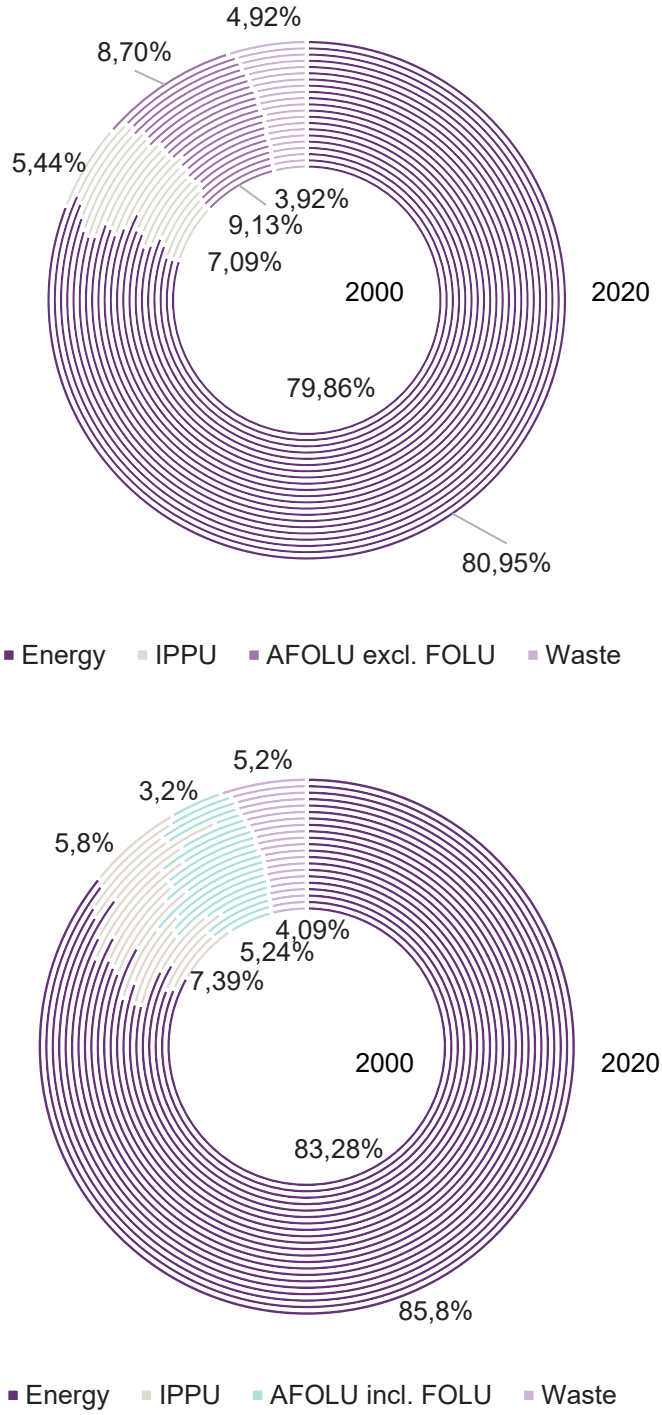

Figure 2-6: Distribution of gross GHG emissions (top) and net GHG emissions (bottom) for South African (2000 to 2020), disaggregated by sector

2.5.1 Emissions Trends per Gas

South Africa's net GHG emissions in 2020 were predominately CO_2 (82.3%), followed by CH_4 (13.4%) and N_2O (3.2%), with F-gas (HFC and PFC emissions) contributing 1.1%, (Figure 2-7). The CO_2 emissions decreased by 2.6% from 2000 to 2020, with CH_4 and N_2O emissions increasing by 1.8%

and 5.1% respectively during this time period. F-gas saw a 414% increase from 2000 to 2020. HFC emissions from refrigeration were included from 2005 (contributing to a 74% increase from 2000 to 2005) and HFC emissions from the remainder of the Other Ozone Depleting Substances sub-sectors, excluding solvents, were included from 2011 (contributing to a 377% increase from 2000 to 2011). With respect to South Africa's gross GHG Inventory, CO_2 emissions decreased by 0.6% and CH_4 and N_2O emissions increased by 2.5% and 6.5%, respectively.

The Energy sector is by far the largest contributor to CO_2 emissions accounting for 94.7%, excluding FOLU. In terms of CH_4, the AFOLU sectors attributed 51.1% to CH_4 emissions, followed by the Waste sector (38.2%). The AFOLU sector (excluding FOLU) accounted for 69.8% of N_2O emissions, with the Energy sector accounting for 17.9%. The IPPU sector is responsible for 100% of F-gas emissions.

Carbon monoxide (CO), nitrogen oxides (NOx) and non-methane volatile organic compounds (NMVOCs) were estimated from biomass burning only. Figure 2-8 shows the estimates emissions between 2000 and 2020. In addition, there is annual variability as the emissions include both wildfires and controlled fires.

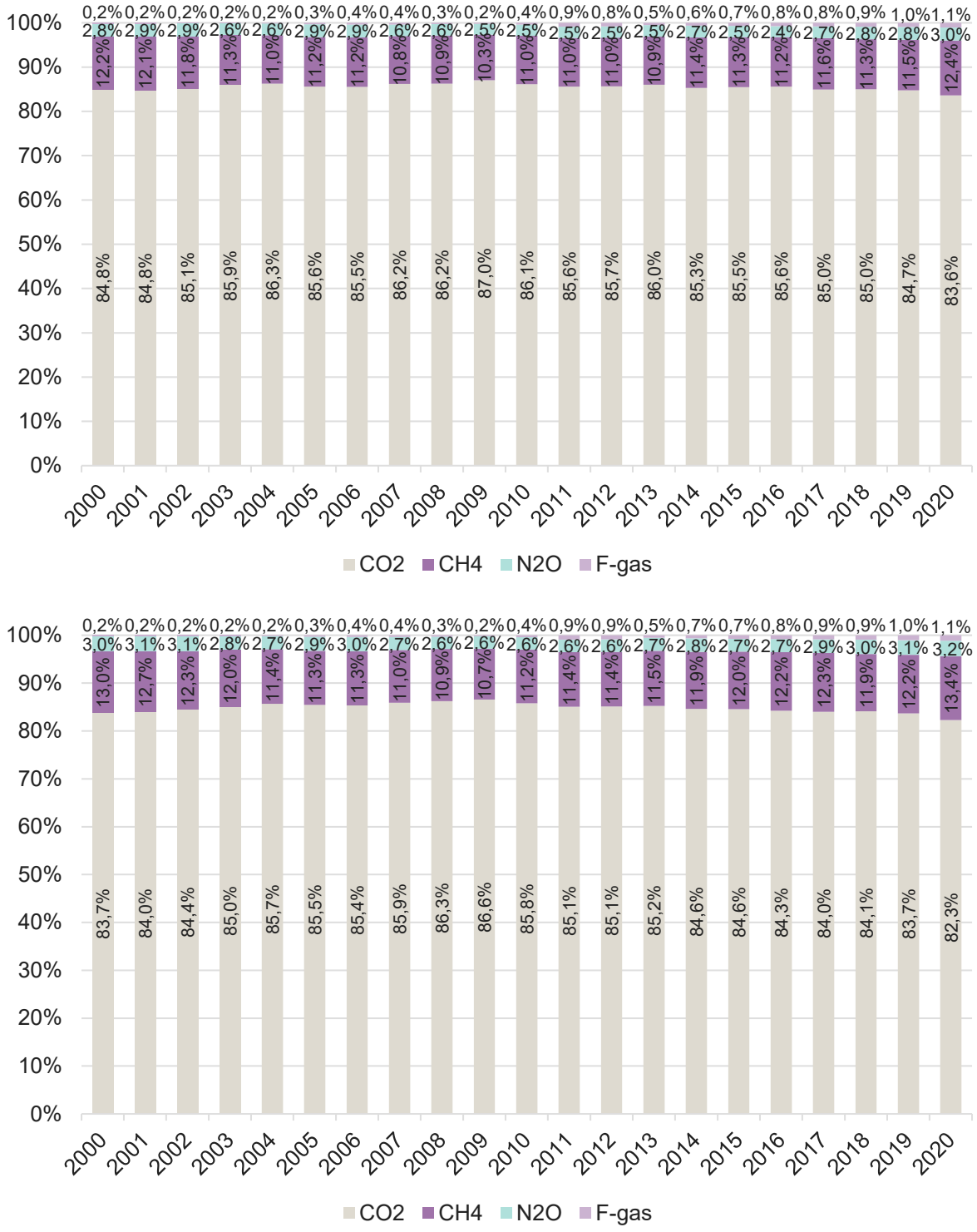

Figure 2-7: Distribution of GHG emissions excluding FOLU (top) and GHG emissions including FOLU (bottom) for South Africa from 2000 to 2020, disaggregated by gas

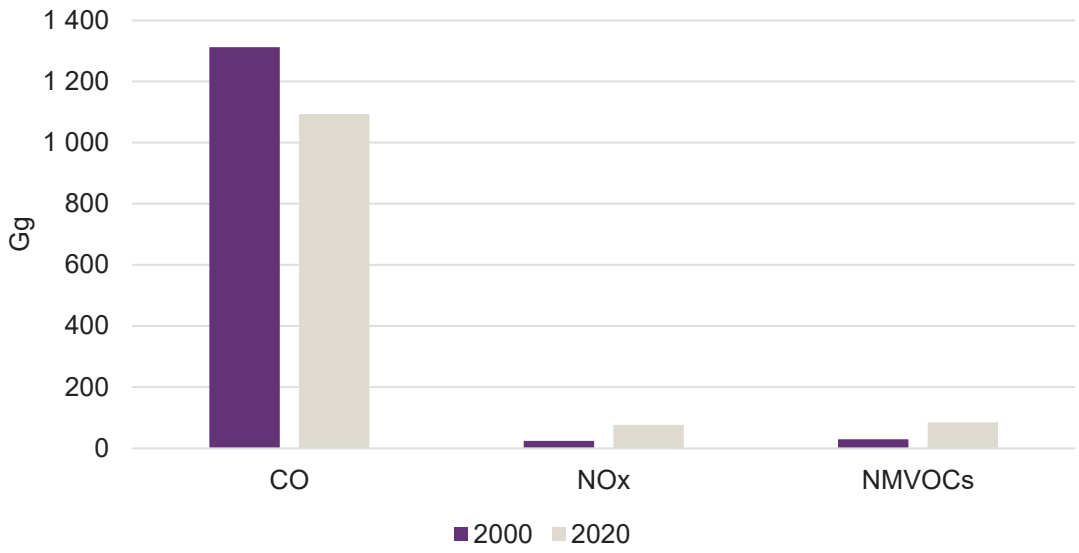

Figure 2-8: GHG precursor emissions in 2000 and 2020

2.6 Emission Trends by IPCC Sector

2.6.1 Energy Sector

The total emissions from the Energy sector for 2020 were estimated to be 379 505 $GgCO_2e$, contributing 81.0% of total emissions (excluding FOLU). The main contributor to Energy sector emissions was Energy industries accounting for 62.4% of emissions (Figure 2-9). This is followed by Transport (12.7%) and Manufacturing industries and construction (8.8%). Fugitive emissions from fuels contribute 8.3% to Energy sector emissions.

Between 2000 and 2020 Energy sector emissions increased by 2.2%. The emissions increased between 2000 and 2009, before declining to 2014 after which total emissions remained relatively stable. Emissions declined by 6.8% in 2020, largely from Other sectors and the Transport sector. This is attributed to the COVID-19 pandemic, which resulted in reduced travel and trading.

Most Energy sector emissions are CO_2, which accounts for 97.9% the sector's emissions. CH_4 and N_2O emissions contribute 1.5% and 0.7% to Energy sector emissions, with the Fugitive emissions from solid fuels attributing 91% to the sector's CH_4 emissions.

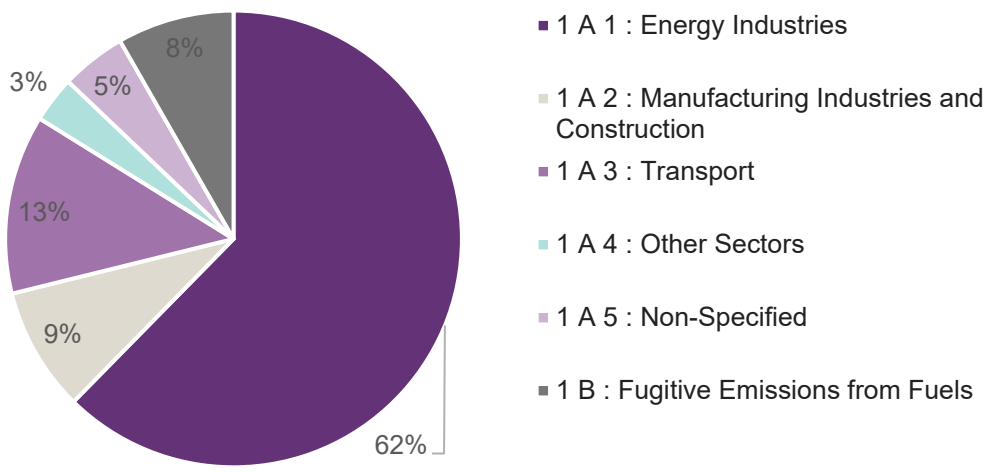

Figure 2-9: South Africa's 2020 Energy emissions, disaggregated per sub-sector

2.6.2 IPPU

In 2020 the IPPU sector contributed an estimated 25 486 $GgCO_2e$ (5.4%) of total emissions (excluding FOLU). The main contributor to IPPU sector emissions was the Metal industry, accounting for 47.9% of emissions (Figure 2-10). This is followed by Product Uses as Substitutes for Ozone Depleting Substances (19.4%) and the Minerals industry (18.7%). The Chemical industry and Non-Energy Products from Fuels and Solvent Use account for 8.9% and 5.1% respectively.

Between 2000 and 2020 IPPU sector emissions decreased by 22.7%. The emissions remained relatively stable between 2000 and 2016, with declines in 2008 and 2009 before increasing moderately to a peak in 2016. Emissions decline sharply in 2017 (19.6%) and continue to decline to 2020.

In the IPPU sector 74.6% of emissions are attributed CO_2, followed by HFCs (19.4%) and N_2O (3.3%). Emissions from CH_4 and PFCs contribute 2.3% and 0.5%, respectively. Product Uses as Substitutes for Ozone Depleting Substances and the Chemical sector contribute to 100% to HFC and N_2O emissions, respectively.

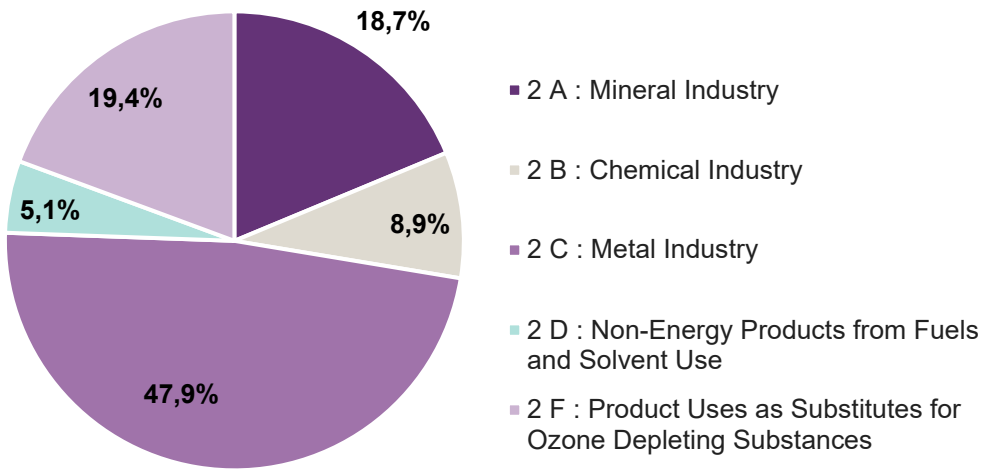

Figure 2-10: South Africa's 2020 IPPU emissions, disaggregated per sub-sector

2.6.3 AFOLU

In 2020 the AFOLU sector contributed 14 088 $GgCO_2e$ (including FOLU) and 40 775 $GgCO_2e$ (excluding FOLU). The Livestock sector contributed 76,9% to total AFOLU emissions (excluding FOLU), of which Enteric fermentation accounted for 87.9% (Figure 2-11). Aggregate Sources and Non-CO_2 Emissions Sources accounted for 23.1% of AFOLU emissions (excluding FOLU) in 2020, 56.1% coming from Direct N_2O Emissions from Managed Soils. For the Land Category, Forest land is the largest contributor to the sink, followed by Grasslands. Other Land is the main CO_2 source in the Land category.

Between 2000 and 2020 AFOLU sector emissions excluding and including FOLU decreased by 3.9% and 39.7% respectively. AFOLU emissions (excluding FOLU) increased up until 2012 before decreasing by 8.9% to 2020. AFOLU emissions (including FOLU) increased reaching a peak in 2008 (58 959 $GgCO_2e$) and then decreased by 76.1% between 2008 and 2020.

The AFOLU sector has significant CH_4 and N_2O emissions, accounting for 51.1% and 69.8% total CH_4 and N_2O emissions (excluding FOLU). Within the sector (excluding FOLU) CH_4 and N_2O emissions account for 72.6% and 23.7% of emissions respectively. CH_4 emissions largely arise from Enteric fermentation (attributing 93.2%). Direct N_2O emissions from managed soils is the most significant contributor to the sector's N_2O emissions (54.6%), along with Manure management (27.0%). When accounting for FOLU emissions, the sector is a carbon sink.

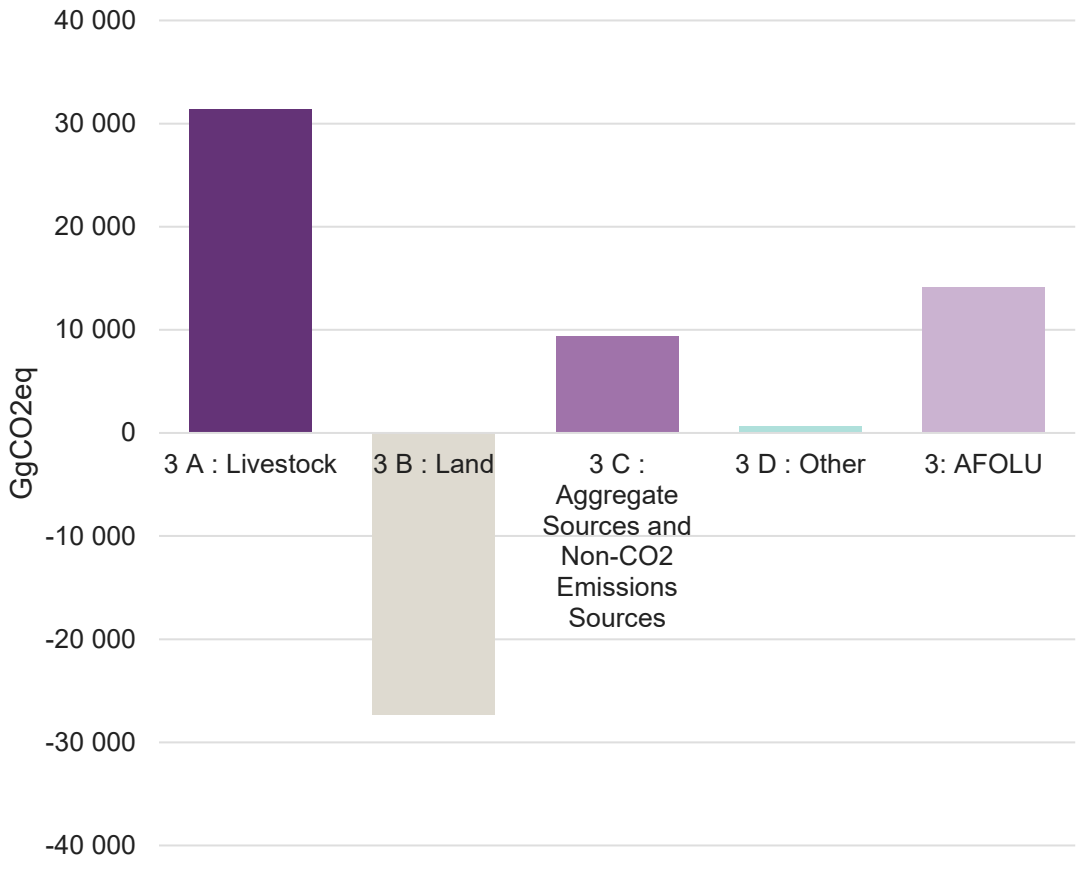

Figure 2-11: South Africa's 2020 AFOLU emissions, disaggregated per sub-sector

2.6.4 Waste

The total emissions for the Waste sector in 2020 were an estimated 23 046 $GgCO_2e$, 4.9% of total emissions (excluding FOLU). The main contributor to Waste sector emissions is the Solid Waste Disposal accounting for 79.2% of emissions (Figure 2-12). This is followed by Wastewater Treatment and Discharge (19.3%) and Incineration and Open Burning of Waste (1.5%). Waste sector emissions increased by 26.3% between 2000 and 2020. The emissions have increased steadily from 2000 (on average over 1% per year), reaching a peak in 2020.

CH_4 emissions account for 96.1% of the Waste sectors total emissions, followed by N_2O emissions (3.7%) and, to a much lesser extent, CO_2 emissions (0.2%).

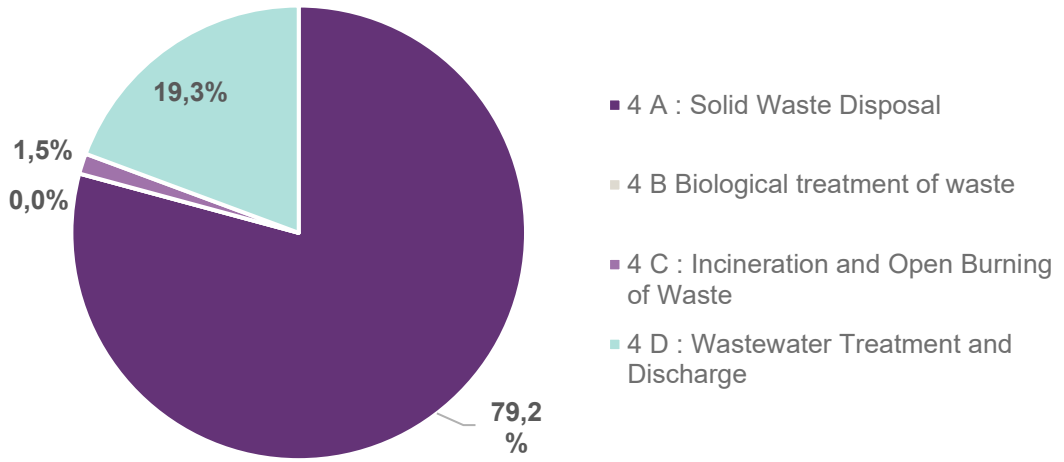

Figure 2-12: South Africa's 2020 Waste emissions, disaggregated per sub-sector

2.7 Key Category Analysis

The latest GHG Inventory includes 58 key categories, an increase from 44 in the previous inventory. Table 2-5 shows the top 30 key categories for South Africa in 2020, with Electricity and Heat production (solid fuels) at number one (up from second place in the previous inventory). The Commercial/Institutional category moved down the ranking from third in the previous inventory to 20th place in 2020. This is because its contribution was reduced significantly likely due to COVID-19. It has been replaced with Forest land remaining forest land in third place. Solid waste disposal has moved to 4th place in the 2020 inventory from 7th place in the previous inventory.

Table 2-5: Top 30 key categories for South Africa for 2020 (including FOLU) and their ranking (DFFE, 2022)

Rank	IPCC Category Code	IPCC Category	GHG
1	1A1a	Electricity and Heat Production (Solid fuel)	CO_2
2	1A3b	Road Transportation (liquid fuel)	CO_2
3	3B1a	Forest land remaining forest land	CO_2
4	4A	Solid Waste Disposal	CH_4
5	1A5a	Stationary (solid fuel)	CO_2
6	1B3	Other Emissions from Energy Production	CO_2
7	3A1a	Enteric Fermentation – cattle	CH_4
8	1A1c	Manufacture of Solid Fuels and Other Energy Industries (liquid fuel)	CO_2
9	1A2	Manufacturing Industries and Construction (solid fuel)	CO_2
10	1A4c	Agriculture/Forestry/Fishing/Fish Farms (liquid fuels)	CO_2
11	2C1	Iron and steel production	CO_2

Rank	IPCC Category Code	IPCC Category	GHG
12	2F1	Refrigeration and Air Conditioning	HFCs
13	1A2	Manufacturing Industries and Construction (liquid fuel)	CO_2
14	1A1a	Main Activity Electricity and Heat Production (liquid fuel)	CO_2
15	2C2	Ferroalloys production	CO_2
16	3C4	Direct N2O Emissions from Managed Soils	N_2O
17	3A1c	Enteric Fermentation – sheep	CH_4
18	3B1b	Land converted to forest land	CO_2
19	1A3d	Water-borne Navigation (liquid fuel)	CO_2
20	1A4a	Commercial/institutional (solid fuel)	CO_2
21	1A2	Manufacturing Industries and Construction (gas)	CO_2
22	1A4b	Residential (solid fuel)	CO_2
23	4D1	Wastewater Treatment and Discharge	CH_4
24	1A4b	Residential (liquid)	CO_2
25	1B1a	Coal mining and handling	CH_4
26	3B3b	Land converted to grassland	CO_2
27	1A1b	Petroleum refining (gas)	CO_2
28	3B5a	Settlements remaining settlements	CO_2
29	3B2b	Land converted to cropland	CO_2
30	3D1	Harvested Wood Products	CO_2

2.8 The GHG Improvement Programme

The National Greenhouse Improvement Programme (GHGIP) is a series of projects that aim to improve activity data, country-specific methodologies and emissions factors used in the most significant sectors. Table 2-6 summarises some of the projects that have been completed as part of the GHGIP. The sections that follow provide details in the planned improvement as well as timelines for each sector as well as cross-cutting improvements.

Table 2-6: Completed DFFE and donor funded GHGIP projects

Sector/project	Baseline	Nature of methodological improvement	Partner	Status
DFFE driven GHGIP projects				
IPPU → Ferro-alloy production	Using a combination of IPCC default factors and assumptions based on material flows	Shift towards an IPCC Tier 2 approach	Xstrata, Ferro-Alloy Producers' Association	Completed December 2020
Energy	Gaps in activity data	Fuel consumption survey, activity data improvement	GIZ and DoE	Completed December 2020

Sector/project	Baseline	Nature of methodological improvement	Partner	Status
Agriculture	Improving the parameters which are required to calculate the country specific EFs for Enteric fermentation and manure management	Improvement of Agricultural Greenhouse Gas Activity data in South Africa: Enteric Fermentation and Manure Management	WRI	Completed December 2020
Donor-funded GHGIP projects				
Energy → Liquid fuels study	-	Country-specific CO_2 emission factors developed to enable reporting of liquid fuels emissions using a tier 2 approach.	GIZ and SAPIA	Completed 2022
Energy → Cement sector study	-	Country-specific CO_2 emission factors developed to enable reporting of alternative fuels emissions using a tier 2 approach.	GIZ and ACMP	Completed 2022

The DFFE is implementing and will be implementing several donor-funded GHGIP projects in the Energy and IPPU sector, presented in the table below.

Table 2-7: Donor funded GHGIP projects

Project	Objective	Partner	Outcome	Status	Timelines
Transport sector study	Development of Country-Specific Emission Factors (Methane and Nitrous Oxides) for transport sector	GIZ DoT	Shift towards an IPCC Tier 2 approach	Not started	2023
Refrigeration and conditioning sector study	HFC Survey in the Refrigeration Sector and Air Conditioning Sector.	GIZ	Improvement of activity data for the sector	Not started	2023
Solid fuels study	Development of CO_2 Emission Factors for Solid Fuels in South Africa	GIZ	Country-specific CO_2 emission factors developed to enable reporting of solid fuels emissions using a tier 2 approach.	In progress	2023

Cross-cutting Improvements

Table 2-8 summarises the cross-cutting completed, in progress and outstanding improvements.

Table 2-8: Cross-cutting planned improvements and timelines

Improvement	Priority	Reason	Status	Completed timeframe	Barriers and constraints
Incorporate data from SAGERS	High	Accuracy	Completed	5th BUR (2020 Inventory)	Data will continue to be incorporated into the future
Set of MOUs with key data providers (e.g., DMRE, SAPIA)	High	Transparency	Resolved	N/A	This has been difficult and is not working. Regulatory processes (NGERs) and the GHGIP are being used for data gathering instead
Improve understanding of differences between reference and sectoral approach	Medium	Key category, transparency	Resolved	5th BUR (2020 inventory)	Updates were made to the Energy Balance data and the actual methodology and calculation file for the reference approach was reassessed. Data was incorporated into the energy sector calculation file.
Improve transparency in reporting by including more detailed description of methodologies and activity data, particularly in energy and IPPU sectors.	High	Transparency	In progress	5th BUR (2020 inventory)	Transparency in the Energy and IPPU sectors were enhanced, however this is an ongoing activity and further updates will be made in the next inventory.
Improve the improvement plan by incorporating all review activities not addressed in current inventory.	High	Transparency	In progress	5th BUR (2020 inventory)	Partly resolved. Challenges around inclusion of further improvements into the improvement plan are limited resources and process management. The DFFE inventory team has increased in size, but it is still taking time to completely address all the issues. The review outputs are included in this report as a reminder of what still needs to be completed.
Incorporate NO_x, CO, NMVOC, and SO_x emissions.	High	Completeness	In progress	5th BUR (2020 inventory)	Partly resolved. NOx, CO and NMVOCs emissions from Biomass Burning were estimated.

Improvement	Priority	Reason	Status	Completed timeframe	Barriers and constraints
Improve uncertainty data for all sectors but incorporating more country specific uncertainty values	Medium	Accuracy	Proposed	Incorporated as data becomes available	Lack of uncertainty data constrains this activity. As data becomes available it will be incorporated, but there are no specific planned projects for this activity at this stage.
Extend time-series back to 1990 for energy, IPPU and waste sectors.	Medium	Completeness	Proposed	Future inventories	Lack of data for years prior to 2000, particularly for categories where data is highly variable (such as HFCs and PFCs), have constrained the completion of this task. A study is planned to extend/extrapolate the data back to 1990 for the three IPCC sectors.
Investigate inconsistencies in lime activity data (for lime production in IPPU and lime application emission in AFOLU), explore alternative data sources or improve consistency.	Low	Consistency	Planned	Future inventories	Not resolved. Various methods were compared but give varying results. Alternative data sources have not yet been found, but it may be possible to collect further data through the SAGERS system in future.
Improve QA/QC process by addressing all issues in external review	High	Transparency	In progress	1st BTR (Next inventory)	Challenges in addressing external review comments have been limited by resources and process management. The DFFE inventory team has increased in size which should assist in addressing this issue. There are still many issues not resolved but the inventory team is working through them. It is an ongoing process.

2.9 Sectoral Improvements

Table 2-9, Table 2-10 summarise the planned improvements and timelines for the Energy, IPPU, AFOLU and Waste sectors respectively.

Table 2-9: Energy sector planned improvements and timeline

Improvement	Priority	Reason	Status	Completed timeframe	Barriers and constraints
Developed EFs, carbon content of fuels and NCVs of liquid fuels	High	Key category, accuracy	Completed	1st BTR (next inventory)	Study was completed in 2022 for most used liquid fuels. Developed parameters to be used in the next inventory.
CO_2 and CH_4 fugitive emissions from oil and natural gas operations	Medium	Completeness	In progress	5th BUR (2020 inventory)	Partly resolved. CO_2 emissions from Oil are included. Further gases from this source category will be added in the next inventory as information will be obtained through NGERs.
Improve explanation of large changes in trends	High	Transparency	In progress	5th BUR (2020 inventory)	Partly resolved. Additional explanations have been provided, but there are still areas where this can be improved further. Ongoing process.
CO_2, CH_4 and N_2O from spontaneous combustion of coal seams.	Low	Completeness	Planned	1st BTR (Next inventory)	New research work on sources of emissions from this category are being evaluated and will be used to report emissions in future inventories.
CH4 emissions from abandoned mines	Low	Completeness	Proposed	Future inventories	New research work on sources of emissions from this category are being evaluated and will be used to report emissions in future inventories.
Fugitive emissions from coke production to be reported separately from 2C process emissions	Low	Transparency	Planned	Future inventories	Progress on this has been slow but reporting through the NGER will allow this activity to be incorporated in the next inventory.
Incorporate emissions from biogas	Low	Completeness	Proposed	Future inventories	This would require a study, therefore, should be recommended as a project under the GHGIP.
CO_2 transport and storage	Low	Completeness	Proposed	Future inventories	Proposed but nothing planned.
CO_2, CH_4 and N_2O emissions	Medium	Completeness	Proposed	Future inventories	Proposed but nothing planned.

from combined heat and power (CHP) combustion systems					

Table 2-10: IPPU sector planned improvements and timeline

Improvement	Priority	Reason	Status	Completed timeframe	Barriers and constraints
Calculated CH_4 emissions from iron and steel production.	High	Key category, completeness	Completed	5th BUR (2020 inventory)	Completed
Estimate emissions from OPUC category using currently available data	Medium	Completeness	Completed	5th BUR (2020 inventory)	Completed for ceramics, soda ash usage and dolomite usage
Development of country specific EF for ferroalloy industry	Medium	Key category; Accuracy	Proposed	Future inventories	Resources and funding are required to complete this study, so it will be incorporated into the GHGIP.
Include emissions from electronics industry	Medium	Completeness	Planned	Future inventories	A study needs to be undertaken to understand emissions from this source so it should be highlighted as a project for the GHGIP.
Incorporate emissions SF6 emissions	Medium	Completeness	In progress	1st BTR (Next inventory)	Lack of data is still a challenge.
Investigate historical data for the imports and exports of clinker	Medium	Completeness	Proposed	Future inventories	TBC
Undertake a completeness assessment to determine if non-marketed lime is reported	Medium	Completeness	Proposed	Future inventories	TBC
Disaggregate the cullet ratio by facility.	Medium	Completeness	Proposed	Future inventories	TBC
Investigate the availability of the historical data (2B6)	Medium	Completeness	Proposed	Future inventories	TBC
Investigate the air quality database for those data providers that trigger reporting under Lead Battery processing	Medium	Completeness	Proposed	Future inventories	TBC

Improvement	Priority	Reason	Status	Completed timeframe	Barriers and constraints
Investigate if secondary zinc production occurs in South Africa Investigate the air quality database regarding pyrometallurgical process involving the use of an imperial smelting furnace is used for combined zinc and lead production.	Medium	Completeness	Proposed	Future inventories	TBC
South Africa to undertake a desktop study regarding two-stroke engines and the use of blended lubricant.	Medium	Completeness	Proposed	Future inventories	TBC

Table 2-11 AFOLU sector planned improvements and timeline

Improvement	Priority	Reason	Status	Completed timeframe	Barriers and constraints
Updated HWP with country-specific data	Low	Accuracy	Completed	5th BUR (2020 inventory)	Completed
Incorporate all background data and equations for the Tier 2 calculations on enteric fermentation	High	Key category, accuracy and transparency	Completed	5th BUR (2020 inventory)	Completed
Incorporate updated National Terrestrial Carbon Sinks Assessment (NTCSA) data to improve estimates, particularly soils	High	Key category, accuracy	In progress	5th BUR (2020 inventory)	Partly resolved. The NTCSA above-ground woody, above round herbaceous and DOM were included or used as validation data, but not as a Tier 3 approach due to there being only one year of data for woody biomass. A QGIS plugin was developed with the last update, and this is currently being explored to determine whether the sinks data can be updated for the additional years to allow for the use of the stock difference approach. A study needs

Improvement	Priority	Reason	Status	Completed timeframe	Barriers and constraints
					to be undertaken to fully incorporate the carbon sinks data and to conduct an uncertainty assessment on the data. This could be a project for the GHGIP.
Include deadwood in the DOM pool for all land categories	Low	Completeness	In progress	1st BTR (Next inventory)	Partly resolved. Deadwood was included for forest land categories.
Include CO2 estimates for wetlands	Low	Completeness	In progress	Future inventories	Partly resolved. Wetlands were assumed to be mineral inland wetlands and CO2 estimates were incorporated on this basis. The data from the Blue Carbon study should however be used to update this in future inventories and include other wetlands and mangroves.
Include 2018 and 2020 SANLC maps	High	Key category;	In progress	1st BTR (next inventory)	Partly resolved. The 2018 and 2020 SANLC maps were developed using Sentinel 2 data as opposed to the Landsat data that was used for 1990 and 2014. This posed some challenges as there was some reclassification of the land types which led to large area changes. The 2018 map was degraded to compare with the 1990 and 2014 maps and an assessment of the natural land change classes was completed. In this inventory the 1990-2018 matrix was applied with some assumptions based on the land change data assessment. At this stage the 2020 data has not been included as it needs to be assessed in terms of the reclassifications, particularly for the natural land classes, but it will be included in the next inventory. DFFE is currently trying to obtain

Improvement	Priority	Reason	Status	Completed timeframe	Barriers and constraints
					annual maps of the 8 natural land classes to be able to assist in separating out actual change from natural seasonal change. This is a high priority.
Improve manure management data, including biogas digesters as a management system	Medium	Accuracy	Proposed	Future inventories	Proposed project as there is a high variability in this dataset.
Incorporate organic soils study to include emissions from organic soils	Medium	Completeness	Planned	Future inventories	Not resolved. Due to the other more pressing issues relating to land this was not a priority and will be incorporated once the land mapping system is running.
Complete an assessment of crop types and areas and investigate discrepancies between crop statistics and NLC data	Medium	Consistency; Comparability	Planned	Future inventories	Variability in crop classifications from the various data sources have made this challenging. Funding will be required to complete a proper assessment of croplands so this project can be included in the GHGIP.
Improve HWP model by incorporating further country specific data and by comparing the production method to the atmospheric model.	Medium	Key category; Accuracy	Proposed	Future inventories	Proposed project that could be considered under the GHGIP.
Complete a full uncertainty analysis for the Land sector, including area bias corrections	High	Key category; Accuracy	Proposed	Future inventories	Proposed to conduct a study to complete an uncertainty analysis for the Land sector, include all spatial data. This could be a project for the NGHGIP.

Table 2-12: Waste sector planned improvements and timeline

Improvement	Priority	Reason	Status	Completed timeframe	Barriers and constraints
Include information on population distribution in rural and urban areas as a function of income	Medium	Key category, accuracy	Completed	5th BUR (2020 inventory)	Study was completed in March 2020 and data is included in the 2020 Inventory
Data collection on quantities of waste disposed of into managed and unmanaged landfills		Key category, accuracy	In progress	1st BTR (next inventory)	Project is completed. Some of the results will be incorporated in the next inventory.
Improve MCF and rate constants		Key category; Accuracy	Proposed	To be considered as a long-term project.	This would require a study, so this will be recommended as a project under the GHGIP.
Include economic data for different population groups		Key category; Accuracy	In progress	Future inventories	
Include HWP in solid waste	Medium	Key category; Completeness	Proposed	To be considered as a long-term.	Insufficient data.
Obtain data on waste streams and the bucket system.		Accuracy	In progress	Future inventories	
CO_2, CH_4 and N_2O from waste incineration	High	Completeness	Proposed	Future inventories	

2.10 References

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3 South Africa's Measures Undertaken to Mitigate Climate Change

3.1 Introduction

South Africa has made substantial strides in its efforts to mitigate the impacts of climate change on people and the economy in a manner that leaves no one behind. In the international context, South Africa has taken a strong stance on climate change and mitigation, beginning with its accession to the United Nations Framework Convention on Climate Change (UNFCCC) in 1997. South Africa ratified the Kyoto Protocol in 2002, and in 2010 under the Copenhagen Accord, it was one of the first developing countries to sign a voluntary emissions reduction pledge for 2020. South Africa hosted COP17 in 2011, which led to the launch of the Durban Platform for Enhanced Action, a new negotiating process to develop a "protocol, another legal instrument, or agreed outcome with legal force" (UNFCCC, 2014). South Africa submitted its first intended Nationally Determined Contribution (NDC) on 25 September 2015, which became the country's first NDC on 1 November 2016 in the lead-up to the Paris Agreement, which it ratified later that month (RSA, 2021c). In the first NDC, South Africa committed to reducing GHG emissions, compared to business as usual, by 34% in 2020 and 42% in 2025 (RSA, 2021c; CAT, 2022).

In September 2021, South Africa submitted an updated NDC, including new, more ambitious mitigation targets for 2025 and 2030 (Figure). The update strengthened the country's target range and represented a significant progression from the first NDC (in the updated NDC, the upper end is reduced by 31% and the lower end by 12% compared to the previous NDC 2016 (RSA, 2021c; CAT, 2022)). The updated NDC considers South Africa's national circumstances and developing country status and common but differentiated responsibility as well as the need to limit global warming to 1.5°C below pre-industrial levels as per the 2015 Paris Agreement. Reaching the updated NDC targets will require numerous efforts that include financial mobilisation, enhancing institutional capabilities, establishing the right financial environment that align fiscal strategies with sustainable growth, and developing and implementing ambitious policies and measures geared towards a low-carbon economy (DFFE, 2020c).

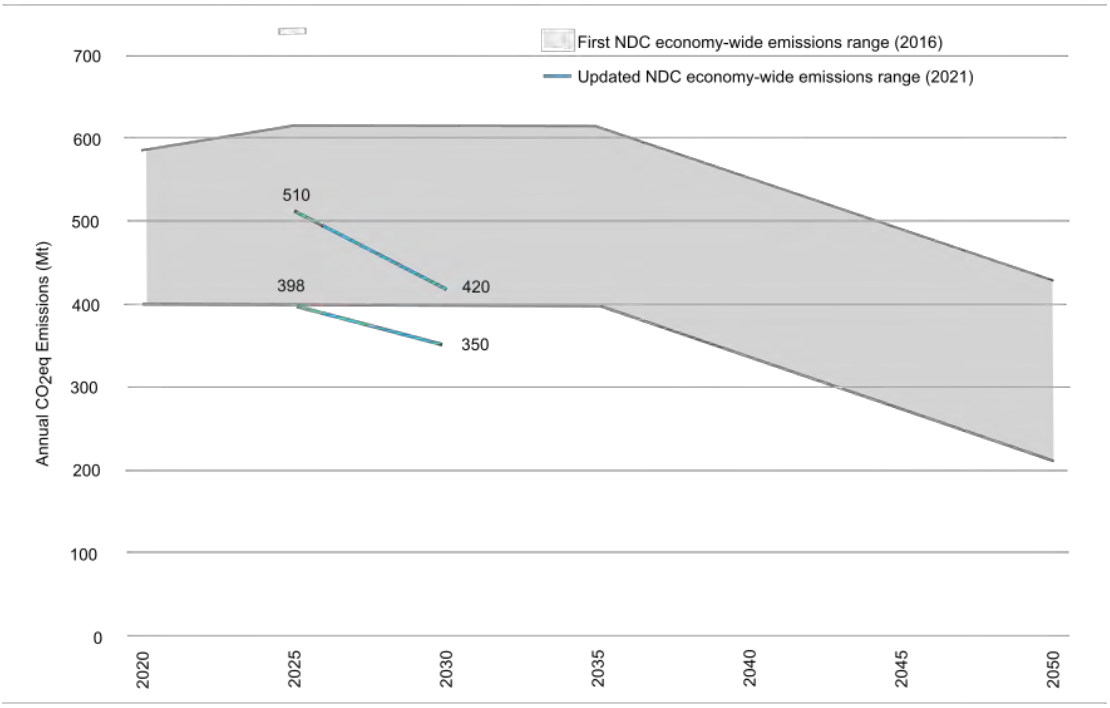

Figure 3-1: South Africa's first and updated NDC (Tyler and Steyn, 2021)

South Africa's long-term climate ambition is outlined in the country's Low-Emissions Development Strategy (LEDS) (DFFE, 2020c). First launched in 2011, the plan has undergone several revisions, with the latest version released in 2019. The country's Low Emissions Development Strategy envisions that: "South Africa follows a low-carbon growth trajectory while making a fair contribution to the global effort to limit the average temperature increase, while ensuring a Just Transition and building of the country's resilience to climate change" (DFFE, 2020c).

The LEDS was developed from extensive knowledge and years of work on climate change, which has contributed to establishing an essential set of policies. While the LEDS was built on existing plans and programs; three key climate policy documents provide the foundation for developing South Africa's LEDS (DFFE, 2020c). These are:

- The National Development Plan (NDP) 2030 calls for eradicating poverty and inequality by 2030 and outlines goals and actions to reach the country's environmental sustainability needs (RSA, 2012; DFFE, 2020c).
- The National Climate Change Response Policy (NCCRP) puts forth the Government's comprehensive policy framework to address climate change impacts, including mitigation and adaptation aspects (RSA, 2011).
- The Climate Change Bill forms the "legislative foundation for the climate change adaptation and mitigation response" (DFFE, 2020c). Concerning mitigation, the Bill provides for "future review and determination of the national greenhouse gas emissions trajectory; determination of sectoral emissions targets for emitting sectors and subsectors; and allocation of carbon budgets" (DFFE, 2020c; RSA, 2022a).

The LEDS provides a long-term perspective on South Africa's mitigation targets and outlines the path towards the aspiration of net-zero greenhouse gas (GHG) emissions in 2050 while ensuring a Just Transition for all. Figure 3-2 presents the historical GHG emissions per the National GHG Inventory Report (2010 – 2017), the initial and updated NDC long-term target ranges, and the 5-year Just Energy Transition Investment Plan (JET-IP) that will catalyse climate action to reach the updated NDC targets most ambitiously (RSA, 2022b).

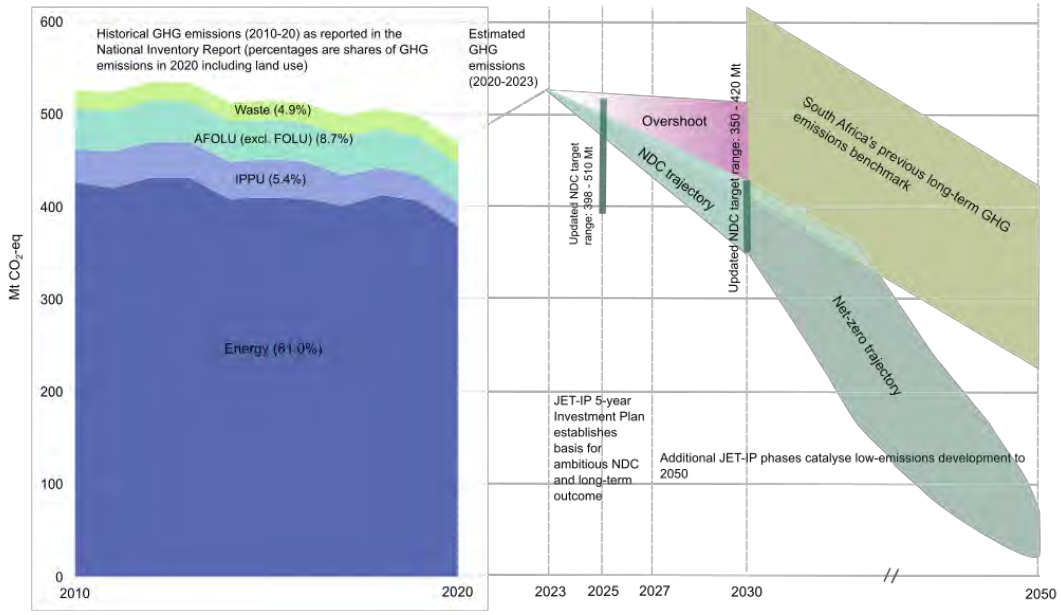

Figure 3-2: Historical emissions, the updated 2030 NDC target, and the long-term pathway to net-zero CO_2 emissions around 2050 (RSA, 2022b)

3.2 A Just Energy Transition

As one of the top 20 carbon-intensive economies in the world, South Africa is particularly vulnerable to the impacts of climate change. Unmitigated GHG emission scenarios indicate warming of up to 5 to 8°C (DEA, 2013). These warming conditions will result in drier conditions in the west and south of the country and wetter conditions in the east with unpredictable rainfall patterns across the country. These changes will have critical implications on food and water resources while increasing the vulnerability of poor communities (DFFE, 2020c). The South African government has made significant strides towards mitigating the effects of climate change, with a focus on the decarbonisation of its power systems which align with international efforts (DFFE, 2020c). With an understanding that this transition needs to be just and equitable for all, the government places a strong emphasis on the Just Energy Transition, aiming to ensure that the country's transition to a low-carbon economy is accompanied by measures to address poverty and inequality, as well as to create new jobs and promote economic growth.

South Africa's low carbon energy transition requires a critical understanding of justice, equity, diversity, and inclusion. In this context, the South African government's Just Energy Transition agenda takes centre stage in developing and designing policies and programmes. The recently drafted Climate Change Bill was submitted to Parliament in February 2022 and includes the Just Transition imperative as part of the overarching objectives and principles that guide South Africa's response to climate change (RSA, 2022a).

South Africa's Just Transition agenda, which is different but related to the Just Energy Transition agenda, aims to lower the risk faced by the most affected and vulnerable parties, such as low-income communities and small businesses, whilst providing opportunities to maximise economic development and redress historical injustices. South Africa's Just Transition agenda strongly emphasises the shift towards clean energy sources while acknowledging that this change will be challenging, particularly for the workers and communities whose lives and livelihoods are tied to the fossil fuel industries. Managing this transition will require strategies that deal with the unavoidable burdens arising from the transition and those that seize the opportunities offered by the green economy. Table represents the three phases of the Just Transition as outlined in South Africa's LEDS implementation plan. Most of the key actions in the Starting Right phase have been completed or are well underway.

Table 3-1: The three phases of the Just Transition

Phase	Key actions
Starting Right (start immediately and complete by end of 2020/21 financial year).	• Start the process of developing long term plans for each sector, to avoid lock-in to emissions intensive infrastructure and establish the basis for transformation at scale. • Develop approaches for allocation of Sectoral Emissions Targets (SETs) and carbon budgets to high emitting entities. • Develop Sector Jobs Resilience Plans (SJRPs) to support the transition to the low carbon economy and climate resilient society in a just manner. • Identify the institutional, legislative, finance and other changes required to achieve the transformation. • Develop an understanding of the relevant government decisions which need to be taken to achieve the long-term plans. • Develop a monitoring plan.
Turning the corner (start immediately, as appropriate, and complete by 2025)	• Develop and begin to implement detailed transformation plans for each sector, which is supported by the implementation of the SETs, carbon budgets and SJRPs. • Develop investment pathways to support the transformation. • Implement foundational changes to drive down the national trajectory. • Implement the institutional changes to accelerate the rate of transformation and remove barriers.
Massive roll-out (to 2050)	• Roll-out the implementation plans for each sector along with measures to support changes until they become the new reality. • Refine strategies as required, to account for changes in technologies, society and markets.

Source: (DFFE, 2021c)

In December 2020, President Cyril Ramaphosa created the Presidential Climate Commission (PCC), which emanates from the Presidential Jobs Summit held in October 2018, when partners reached an agreement to establish a statutory body responsible for coordinating and supervising the fair transition to a low-carbon, inclusive, and climate change-resilient economy and society. In fulfilling its role, the PCC's focus is to:

- "Create a social partnership around a just transition.
- Define a vision for a just transition, and means of achieving that vision, covering the necessary sectoral shifts, technological innovation, employment opportunities, and climate finance.
- Conduct independent analysis into climate change impacts on jobs, the economy, and policy.
- Monitor progress towards mitigation and adaptation goals, as well as the achievement of a just transition linked to broader development objectives.
- Engage with a wide range of stakeholders, including all spheres of government, business, labour, academia, communities, and civil society" (PCC, no date).

In 2022, the PCC launched its first building block towards this objective: the Just Transition Framework. The Framework builds on the country's response strategy, primarily focusing on aligning policies that will provide guidance and direction where there are contradictory policy directives. It further considers the requirement to balance the reduction of GHG emissions with the impact that this

will have on employment and the need to create long-term green jobs, especially for communities heavily reliant on the fossil fuel industry. It also builds economic, social and climate resilience whilst strengthening coordination and implementation towards the NDC (Ginindza, 2022; PCC, 2022).

The framework is guided by the following shared definition of a Just Transition in South Africa:

“A Just Transition aims to achieve a quality life for all South Africans, in the context of increasing the ability to adapt to the adverse impacts of climate change, fostering climate resilience, and reaching net-zero GHG emissions by 2050, in line with best available science.

A Just Transition contributes to the goals of decent work for all, social inclusion, and the eradication of poverty.

A Just Transition puts people at the centre of decision-making, especially those most impacted, the poor, women, people with disabilities, and the youth - empowering and equipping them for new opportunities of the future.

A Just Transition builds the resilience of the economy and people through affordable, decentralised, diversely owned renewable energy systems; conservation of natural resources; equitable access of water resources; an environment that is not harmful to one’s health and well-being; and sustainable, equitable, inclusive land-use for all, especially for the most vulnerable” (PCC, 2022).

3.3 Policies and Measures to Mitigate Climate Change

The following sections provide an overview of the key policies and measures South Africa has implemented or is currently developing to mitigate the impacts of climate change on the country. These measures aim to reduce GHG emissions, promote sustainable development, and transition towards a low-carbon economy in the context of a Just Transition.

By implementing these policies and measures, South Africa aims to contribute to the global effort to mitigate climate change and build resilience. The policies and measures covered in this section include the overarching policies that affect the economy as a whole, namely the National Climate Change Bill and the Carbon Tax Act 2019, as well as sector-specific policies to reduce emissions. These sectors align with the IPCC sector delineation and include Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land Use (AFOLU), and Waste.

Figure 3 provides an overview of the development of key policies and measures implemented in South Africa over time. It should be noted that the mitigation policy space in South Africa is developing rapidly, and this review of policies and measures is current at the time of writing.

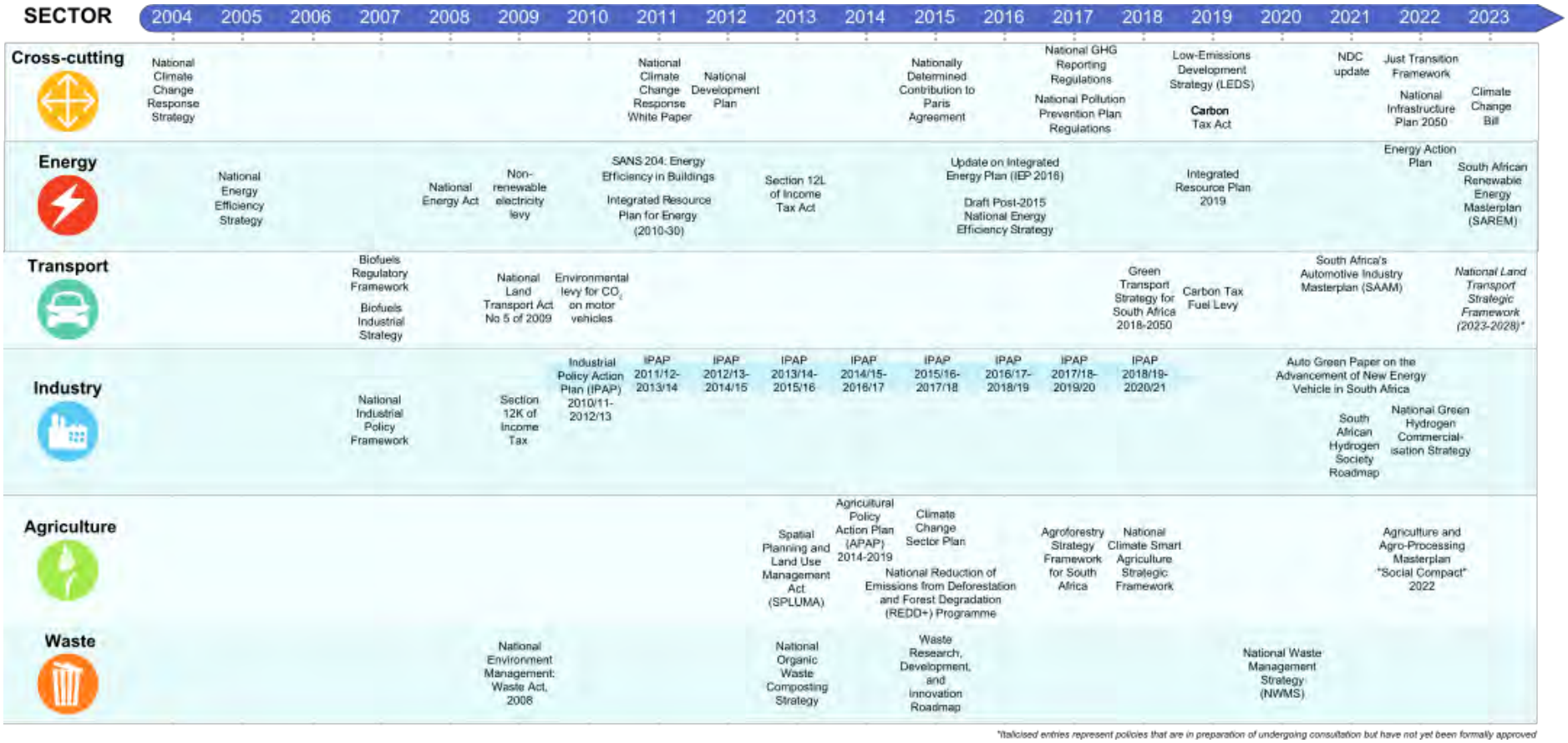

Figure 3-3: Timeline of Key Policies and Measures by Sector (Averchenkova, Gannon and Curran, 2019)

3.3.1 Cross-cutting Policies and Measures

The following section introduces a range of cross-cutting policies and measures specifically designed to lower GHG emissions and facilitate sustainable development, aligning with the principles of a Just Transition and the broader challenge of climate change. Key initiatives, such as the Climate Change Bill and Carbon Tax, along with their supporting policy instruments, illustrated in Figure 3-4, receive more detailed discussion.

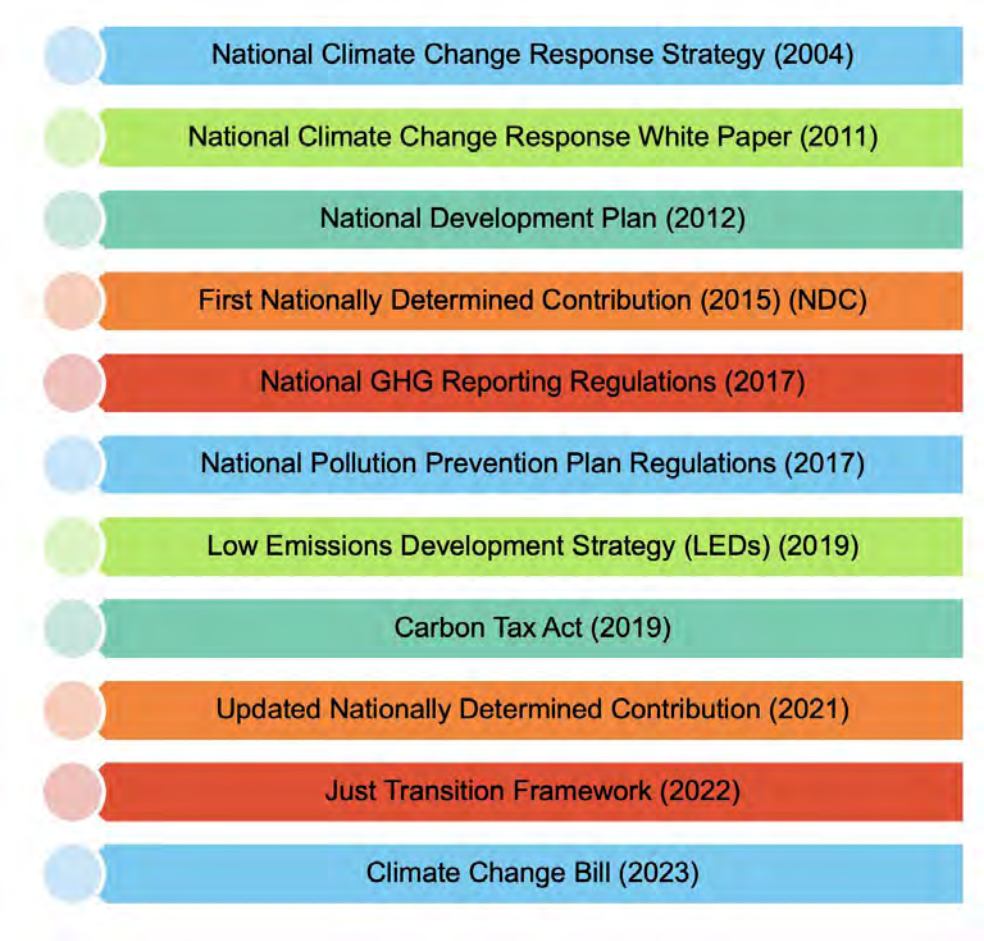

Figure 3-4: Key cross-cutting policies and measures

South Africa's National Climate Change Bill forms the legislative foundation of South Africa's Climate Change policies and was formally introduced in the National Assembly in February 2022 and passed in October 2023. The Bill is the culmination of almost two decades of work, building on the National Climate Change Response Strategy released in 2004 and the National Climate Change Response White Paper of 2011 (DEAT, 2004; DEA, 2011). The Bill intends to "enable the development of an effective climate change response and a long-term, Just Transition to a low-carbon and climate-resilient economy and society for South Africa in the context of sustainable development" (RSA, 2022a).

A key emission reduction instrument is the Sectoral Emission Targets (SETs), previously known as Desired Emission Reduction Outcomes (DEROs) in the National Climate Change Response White Paper (DEA, 2011). The SETs are quantitative, or qualitative GHG emission targets (or aspirations) assigned to government sectors or sub-sectors, intended to be achieved progressively over time. The targets are being developed and will be allocated as soon as the Climate Change Bill becomes law. On 24 October 2023, South Africa's National Assembly voted to pass the Climate Change Bill, and it is

moving ahead through the legislative process. The targets will be determined for three rolling five-year periods, and will be reviewed every five years (DFFE, 2021c). The emitting sectors or sub-sectors must align, adjust, upscale or develop policies and measures (PAMs) to help them achieve their allocated SETs. The current legislative framework, such as the Climate Change Bill, allows different sub-national (local and provincial) government departments to contribute to the SETs process, not just the national sector departments. The Bill allows provincial and local governments to conduct climate change needs and response assessments and develop and implement their climate change response implementation plans together with provincial, regional or district municipalities' planning instruments (DFFE, 2021c).

In March 2021, the DFFE initiated the SETs Framework development process through provincial stakeholder consultations. During the first half of 2021, the department used inputs from stakeholders and the Intergovernmental Committee on Climate Change (IGCCC) members to create a draft framework. The framework was finalised and submitted to Cabinet for approval in the second half of 2022. From September 2022 until 30 December 2023, the "SETs Analysis and Allocation" phase will involve:

- Quantifying PAMs for the SETs.
- Engaging with various DFFE Branches' SETs and Just Transition task teams on Environmental SETs.
- Liaising with line departments (DFFE, 2021c).

Following this phase, the SETs will be finalised and published for implementation. Starting in January 2024, the "SETs Monitoring and Evaluation" phase will commence. Progress on the SETs will be reported quarterly to the IGCCC and provincial committees, while an annual presentation on the implementation of the SETs will be made to Cabinet.

Another key emission reduction instrument under the Climate Change Bill is Carbon Budgets. Section 23(2) of the Bill mandates the Minister of Forestry, Fisheries and Environmental Affairs to assign industry-specific Carbon Budgets to companies or individuals engaged in activities that emit GHGs. Participation in the carbon budget system will be mandatory for all GHG emitters per the Climate Change Bill.

The DFFE has implemented a phased approach towards carbon budget implementation (See Figure 4 for an illustration of the development of the carbon budgets). The first phase, from 2016 to 2020, followed the promulgation of the National Pollution Plan Regulation in July 2017. During this period, the DFFE encouraged companies to submit their carbon budgets for approval and review, incentivising them with a 5% Carbon Tax allowance. Of the 58 companies that submitted their carbon budget applications, 45 were granted carbon budgets, totalling 338 Mt CO_2eq (annualised) - equivalent to 66% of South Africa's GHG emissions according to the 2015 GHG Inventory. The DFFE's phased approach aims to gradually implement carbon budgets while providing incentives and support to companies.

In October 2020, the Minister introduced a transition period to provide continuity after the first phase of carbon budgeting ended on 31 December 2020. This transition period was intended to run from January 2021 to December 2022, but has since been extended to December 2024. The main objectives of the transition period are to allow adequate time for entities to prepare for the mandatory Phase 2 and submit voluntary budgets (with a 5% carbon budget allowance). During the transition period, extensive stakeholder engagement has been taking place with industry and mining companies to determine appropriate budget allocation methodologies. The outcomes of this engagement process are also being used to inform the mandatory allocation of carbon budgets (DFFE, 2021b).

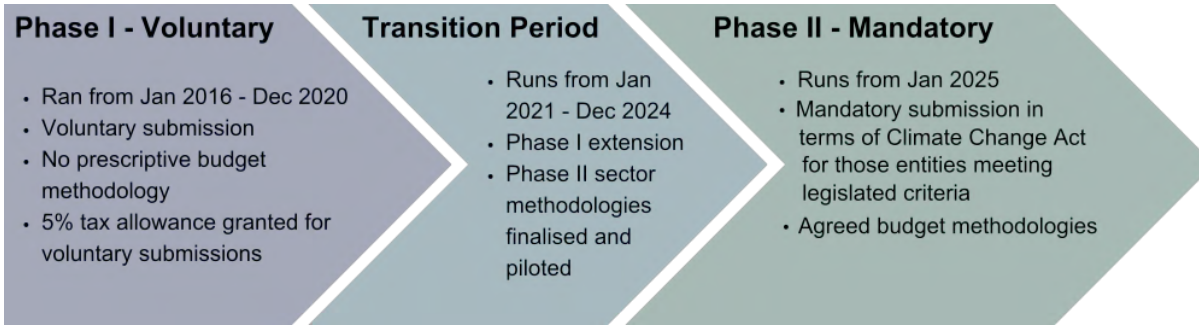

Figure 3-5: The three implementing phases of the Carbon Budgets (DFFE, 2021b)

Several legislative pieces form part of the statutory framework that is relevant to the implementation and management of the carbon budgets:

- **National Climate Change Bill:** the National Carbon Budgets and Mitigation Plans Regulations guide the implementation of Carbon Budgets. The National Climate Change Bill makes provision for mitigation plans in fulfilment of carbon budget obligations. In the event of any conflict between a requirement of the Bill and other legislation specifically relating to climate change, the Climate Change Bill prevails (RSA, 2022a). The Bill has since undergone public consultation and in October 2023, the National Assembly passed the Bill and assigned it to the National Council of Provinces for approval (PMG, 2023).
- **National Carbon Budgets and Mitigation Plans Regulations (in consultation):** the Regulations will define procedural and administrative requirements concerning carbon budgets and mitigation plans provided for in the Climate Change Bill. Activities will govern the mandatory allocation of carbon budgets. The Minister will communicate these activities via Government Gazette as defined by the National Climate Change Bill and the Regulations. Refer to Table 3-2 for the list of emission sources to be included (DFFE, 2021b).
- **National GHG Reporting Regulations (2017):** the calculation and disclosure of emissions data is guided by the gases included in the GHG Reporting Regulations. The gases to be considered for carbon budgets are Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur Hexafluoride (SF_6) and Nitrogen Trifluoride (NF_3) (DEA, 2017a).
- **National Pollution Prevention Plans Regulations (2017):** the mitigation plans disclosed as part of the pollution prevention plans will align to those mandated by the National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) (DEA, 2017b).

Table 3-2: Emission Sources for inclusion in Carbon Budgets

Source Description	Coverage	Implications for the Carbon Budget: Commitment Period 1	Applicability rule for Commitment Period 2 and Commitment Period 3
Stationary Combustion	Mandatory	Emission source forms part of Carbon Budget accounting	Accounting of this emission source forms part of Carbon Budget accounting
Civil aviation			
Domestic navigation			
Fugitive emissions			
Industrial Processes and Product use			
Road Transportation	Voluntary	Once elected, emission source forms part of accounting for Carbon Budgets	If included in Commitment Period 1, emission source remains part of accounting for Carbon Budgets in Commitment Period 2 and Commitment Period 3
Agriculture			
Forestry and land Use			
Waste			
Scope 2 sources	Voluntary	If elected, emission source will not form part of Carbon Budget accounting. Emission savings from scope 2/3 related activities are reported as memo items.	If elected, emission source will not form part of Carbon Budget accounting. Emission savings from scope 2/3 related activities are reported as memo items.
Scope 3 sources			

Source (DFFE, 2021b)

The National Pollution Prevention Plans (PPPs) Regulations, 2017 were adopted on 21 July 2017 as a subsidiary of the National Environmental Management: Air Quality Act 2004 (Act No. 39 of 2004). As per the regulations, section 4(1), a person or companies need to submit a Pollution Prevention Plan for approval by the government if it performs any of the production processes listed in Annexure A of the Regulations (e.g. coal mining, production and, or processing of natural gas, iron and steel production) and emits an excess of 0.1 Mt annually of the priority air pollutants as listed in the regulations (DEA, 2017b). Companies further need to register under section 5 of the National GHG Emission Reporting Regulations (GN 275 of 3 April 2017) as well as submit annual progress reports in terms of regulation 5(1) of the Pollution Prevention Plan Regulations (DEA, 2017a).

Since the last National Communication, South Africa has made significant progress towards implementing a carbon tax. On 1 June 2019, National Treasury promulgated the Carbon Tax Act 15 of 2019 after almost a decade in the works. Aligned with the just transition values, The Carbon Tax Act intends to "balance South Africa's mitigation goals with the need to reduce poverty and maintain trade competitiveness" (WB, 2017). The Carbon Tax gives effect to the international polluter-pays-principle of the National Environmental Management Act (NEMA) and the Climate Change Bill. It helps to ensure that companies and consumers consider climate change's negative, adverse costs in their future production, consumption, and investment decisions.

Initially, the tax rate was set at a base rate of ZAR 120 per tonne CO_2eq. On top of the base rate, several tax-free allowances were built into the carbon tax calculation. This resulted in the effective rate

being as little as ZAR 6 per ton of CO_2eq. National Treasury acknowledged that the original base rate was too low and increased the rate annually by inflation plus 2%, allowing large emitters time to transition to cleaner technologies. From the 1 January 2023, emissions within the carbon budgets are taxed at the statutory carbon tax rate of ZAR 159 per tonne CO_2eq. This rate is expected to increase to ZAR 236 in 2025, reaching ZAR 462 in 2030 (see Figure 3-6) (NT, 2022d). From 2031 onwards, it is anticipated that the tax rate increase will be announced by the Minister in the Budget, with allowances made for periodic adjustments to ensure that the carbon tax rate in Rands is comparable to the global carbon price given exchange rate fluctuations (NT, 2022a).

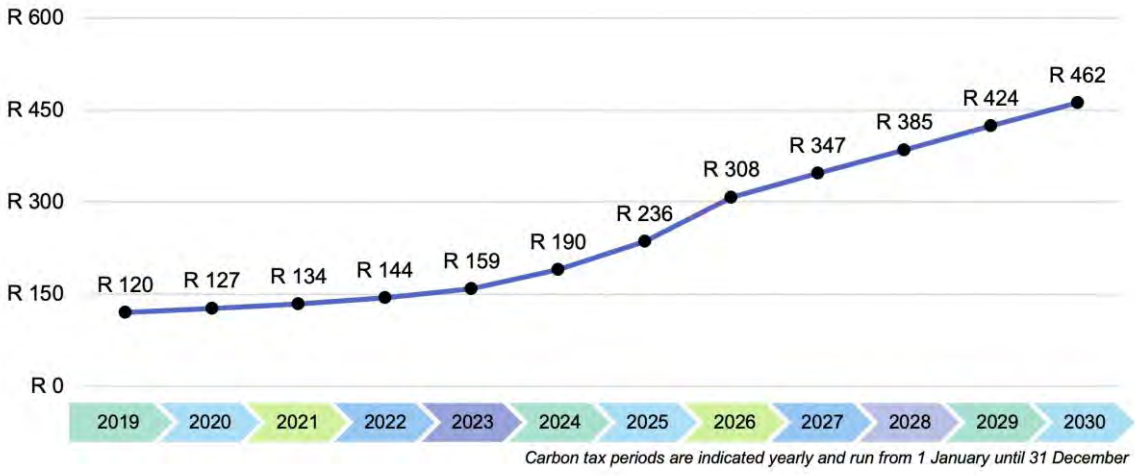

Figure 3-6: South Africa's historical Carbon Tax Rate (2019 – 2023) and projected Carbon Tax Rate (2024 – 2030) (NT, 2022d)

The Carbon Tax is implemented in phases, with the first phase originally planned to end on 31 December 2022 and the second phase to commence on 1 January 2023. However, the 2022 National Budget Review announced an extension of the first phase by three years until 31 December 2025. This extension gives businesses more time and transitional support to navigate the complex carbon tax regime. During this period, GHG emitters will continue to receive tax-free allowances and revenue recycling measures that reduce their carbon tax liability (NT, 2022a).

Figure 3-7 provides a visual representation of South Africa's carbon tax and budget policies' timelines.

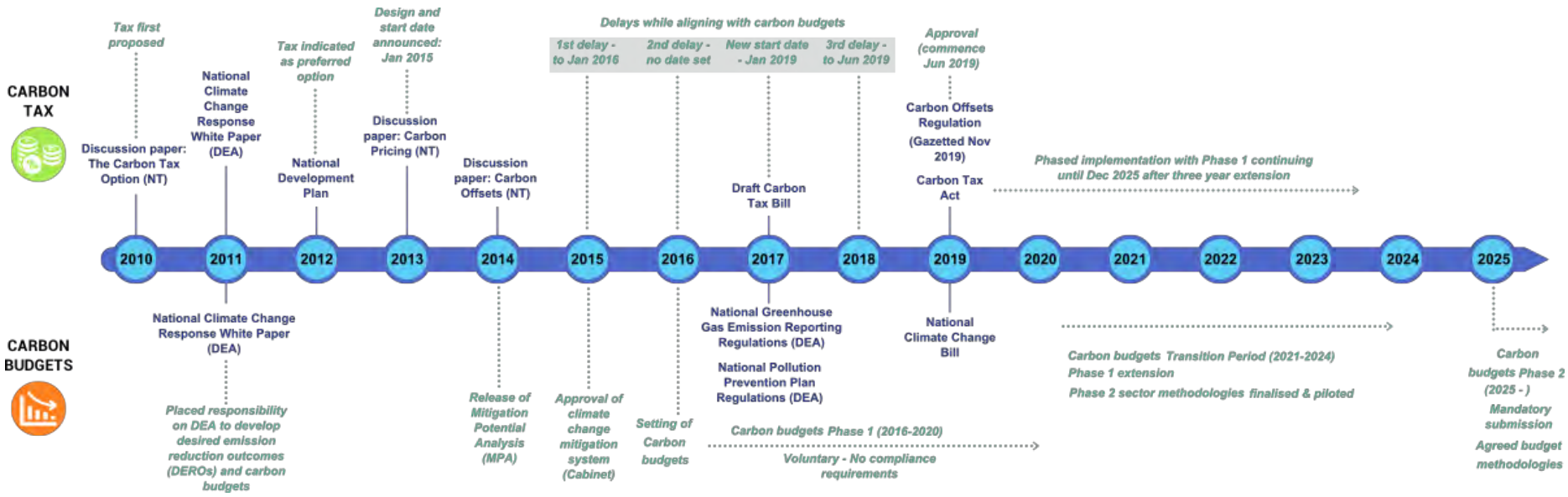

Figure 3-7 Policy Timeline for South Africa's Carbon Tax and Carbon Budgets (Averchenkova, Gannon and Curran, 2019)

Section 19(c) of the Carbon Tax Act provides for Carbon Offsets, and in November 2019, the Carbon Offset Regulations were published (RSA, 2018a). The carbon offsets system is one mechanism under the Carbon Tax that can assist companies to reduce emissions cost-effectively (DMRE, 2022c).

Carbon offsets refer emissions savings from investments in specific projects or activities that reduce, avoid, or sequester emissions. Entities affected by the carbon tax invest in projects in return for carbon credits to access GHG mitigation options at a lower cost than investment in their current operations. These entities can reduce their tax liability by using carbon offset credits by 5 to 10 percent of their total taxable GHG emissions (RSA, 2018a). The carbon offset system aims to promote the reduction of GHG emissions in sectors or activities that are not directly affected by the tax; projects or activities related to public transport, AFOLU and waste (RSA, 2018a, 2019b).

During the first phase of the carbon tax, companies can use carbon offset credits from projects that comply with three international carbon offset programmes - the Clean Development Mechanism (CDM), Verified Carbon Standard (VCS), and Gold Standard (GS) - to reduce their carbon tax liability (DMRE, 2022c). Companies must cancel eligible offsets in the originating registry before they can be transferred and registered into South Africa's Carbon Offset Administration System (COAS), which the Designated National Authority administers in the Department of Mineral Resources and Energy (DMRE). Currently, 36 projects are listed on the registry with 14,535,440 tCO_2eq listed, and 11,861,460 tCO_2eq retired (RSA, 2023a). The DMRE issues retirement certificates for carbon tax offsets (DMRE, 2022c).

For subsequent phases of the carbon tax, it is envisaged that companies may also utilize domestic South African programmes/ standards approved by the Minister responsible for Energy or delegated authority (RSA, 2018a). The DMRE published the Draft Framework for Approval of Domestic Standards for public comment in January 2022. The domestic programmes/standards should aim to ensure environmental integrity, lower transaction costs, accommodate South Africa-specific projects, provide transparency, accommodate social, economic and environmental co-benefits and withstand international scrutiny (DMRE, 2022c).

Recent developments that promote the uptake and production of carbon offset credits is the joint venture by the Johannesburg Stock Exchange (JSE) and Xpansiv, a leading provider of environmental market technology, to launch a new voluntary carbon market in South Africa. The initiative will allow local participants to buy and sell carbon credits and renewable energy certificates which are held in local or global registries (DMRE, 2022c; Whyte, 2022; Dube, 2023; JSE, 2023). In addition, the Africa Carbon Market Initiative (ACMI) was launched in November 2022 at COP27 to grow the demand for and production of carbon credits on the continent and contribute towards creating sustainable jobs, economic prosperity, and environmental preservation (Gay et al., 2022).

While the carbon offsets system is a crucial policy measure to reduce GHG emissions efficiently, it is also essential to ensure that local carbon offset projects generate sustainable development benefits and low-carbon-oriented employment opportunities in South Africa. South Africa can achieve these benefits by attracting investments in energy efficiency and renewable energy, rural development projects, and initiatives to restore landscapes, reduce land degradation, and protect biodiversity (DMRE, 2022c).

3.3.2 Energy

The Energy sector was responsible for **379,505 Gg CO_2eq** in 2020, contributing over **80%** of the country's greenhouse gas emissions (excluding FOLU) (DFFE, 2022b). Of the energy related emissions in 2020, the breakdown is as follows: Electricity and heat production **54%**, Manufacturing industries and construction (including energy industries other than electricity) **31%,** Transport **13%**, and Commercial and residential sector **<2%.**

South Africa's energy sector is still dominated by coal, which in 2020 contributed 60% to primary energy supply, followed by crude oil, making up 15%, renewable and waste sources, 19%, and gas and nuclear 1% and 2% of primary energy supply respectively (DMRE, 2020a).

This section presents the policies and measures related to the energy sector, which are summarised in the figure below. Transport related policies and measures are presented separately.

Figure 3-8: Key policies and measures for the Energy sector

The White Paper on the Energy Policy of the Republic of South Africa of 1998 envisaged the development of a National Integrated Energy Plan (IEP). According to the National Energy Act, 2008 (Act No. 34 of 2008), the Minister of Energy must develop and publish the IEP and review annually (DoE, 2016b; RSA, 2018b). In November 2016, the Department of Energy (now known as the Department of Mineral Resources and Energy) published the Draft IEP report in the Government Gazette. The draft IEP focused on determining the long-term energy pathway for South Africa for all energy carriers (DoE, 2016b).

The draft IEP report presented four energy scenarios, namely “Base Case”, “Resource Constrained”, “Green Shoots”, and “Environmental Awareness”, with the latter scenario presenting more stringent emission reduction targets and limits (DoE, 2016c, 2016b). However, the draft IEP was never finalised and due to the rapid changes in the sector and economy was soon considered outdated. In April 2023, President Cyril Ramaphosa issued a gazette indicating the imminent release of the IEP report for the 1 April 2024, as is required by Section 6 of the National Energy Act, 2008 (RSA, 2023b). Once implemented, the IEP aims to provide a guiding framework for future energy infrastructure investments and policy development for South Africa. In the interim, the Integrated Resources Plan (IRP), a subset of the IEP, has been used to guide energy infrastructure investments (DoE, no date). Given the electricity supply challenges that the country has faced in recent years, the IRP has been prioritised over the IEP (DoE, no date).

The Integrated Resource Plan (IRP) is South Africa's electricity infrastructure roadmap that drives diversification of the country's electricity mix based on least-cost electricity supply and demand balance (van der Poel, 2019). The IRP 2010-2030 (IRP 2010) was promulgated in March 2011. In

2016, the base case and underlying assumptions were updated and consultations held, with a draft update report published in 2018. The most recent IRP (IRP 2019) was published in 2019 and identified additional generation technology required to supplement the projected electricity demand growth up to 2030 (DoE, 2019). The updated IRP 2019 also explains that its development occurs amidst a backdrop defined by rapid changes in energy technologies and an inherent uncertainty regarding the implications of these technologies (Dempster, 2019). At the time of writing, a further IRP update was imminent.

The IRP has a significant impact on South Africa's climate change mitigation efforts as it not only determines the planned increased uptake of renewable energy, but also the rate of decarbonisation of the electricity sector in terms of retirement of the coal fleet. The IRP 2019 capacity allocations show increased solar photovoltaic (PV) and wind alongside a significant decrease in gas and diesel (Dempster, 2019; DoE, 2019). Furthermore, it includes storage technologies as a plausible solution to harnessing additional renewable energy capacity during periods of low demand, as well as the possibility of increased nuclear capacity in the longer term. Solar concentrated power (CSP) must still be allocated. Notably, "generation for own use allocation" has been replaced by "distributed generation", encompassing all generation facilities dedicated to supplying electricity to end-use customers on the same property, including co-generation, biomass, and landfill gas (Dempster, 2019; van der Poel, 2019).

The contribution of coal to the energy mix is expected to dominate into the foreseeable future (up to the year 2030), with the IRP 2019 anticipating decommissioning of 35 GW of Eskom's coal generation capacity by 2050 (currently Eskom is operating 42 GW) (DoE, 2019; Moisio et al., 2020). Apart from the expected retirement schedule of coal, the retirement timeline of the nuclear power plant, Koeberg, also received attention in the IRP 2019. Work has commenced to extend its design life and nuclear safety license to 2044 (Moisio et al., 2020).

The IRP 2019 further set out nine policy decisions in the short term to minimise the risk of loadshedding and the extensive use of diesel peaking plants. These decisions included:

- "Undertake power purchase programme to acquire capacity;
- Undertake technical and regulatory work for the 20-year extension of the life of the Koeberg nuclear power plant beyond 2024;
- Support Eskom to comply with minimum emissions standards;
- consolidate into a single team the various initiatives for a just transition for purposes of coherent policy development;
- Retain the current annual build limits on renewables (wind and PV) until the finalisation of the just transition plan;
- South Africa should not sterilise the development of its coal resources for purposes of power generation, but instead all new coal power projects must be based on high efficiency, low emission technologies and other cleaner coal technologies;
- Support the development of gas infrastructure and, in addition to the new gas to power capacity, convert all diesel-fired power plants (peakers) to gas;
- Commence preparations for a nuclear build programme to the extent of 2,500MW at a pace and scale that the country can afford because it is a no-regret option in the long term; and
- South Africa will participate in strategic power projects that enable the development of cross-border infrastructure needed for regional energy trading" (van der Poel, 2019).

Despite these recommendations made in the 2019 IRP, South Africa's electricity sector remains in crisis. "Load shedding is the single biggest constraint on South Africa's economic growth" (The Presidency, 2022). An analysis by the Council for Scientific and Industrial Research (CSIR) has shown

that there has been a significant increase in load-shedding hours in 2023 compared to 2022 (Omarjee, 2023). To respond to the country's severe energy crisis, President Ramaphosa established the National Energy Crisis Committee of Ministers (NECOM) to oversee the implementation of an Energy Action Plan that addresses load-shedding and achieves energy security (The Presidency, 2023b). The Energy Action Plan, announced by the President on 25 July 2022, was developed in consultation with expert stakeholders, providing the most optimal path towards energy security. The two main objectives of the plan are to firstly improve the performance of Eskom's existing power stations and secondly, to add as much new generation capacity to the grid as possible by unlocking energy from many different sources, including Eskom, IPPs, businesses and households (The Presidency, 2022).

In response to load-shedding, a growing number of electricity consumers are generating and distributing their energy by installing private small-scale embedded generation (SSEG). SSEGs are defined as smaller than 1 MVA (1000kVA). In South Africa, solar PV is the primary technology type used as an SSEG, but wind, biogas electricity, hydropower and diesel generators connected to the grid are also forms of SSEG. Total SSEG Solar PV installed in the first quarter of 2023 amounted to 620 MW in the residential sector and 1247 MW in the commercial and industrial sector.

A landmark regulatory change was announced by President Cyril Ramaphosa in August 2021, where Schedule 2 of the Electricity Regulation Act was amended to extend the limit over which a private power project must apply for a Generation License, from 1MW to 100MW. The additional energy supply would help reduce the burden on power utility Eskom (NAAMSA, 2023). NERSA has since approved and registered two private 100MW generation projects located in the North West have been approved and registered (Omarjee, 2022).

Another landmark reform is the restructuring of Eskom into separate generation, transmission and distribution divisions as outlined in the Department of Public Enterprises' (DPE) Roadmap for Eskom in a Reformed Electricity Supply industry, published in 2019 (DPE, 2019). In support of the Roadmap, the Electricity Regulations Act 4 of 2006 amended Schedule 2, 2022, which falls into the National Energy Action Plan, provides for a competitive market for electricity generation in the country and broadens the national regulatory framework for the electricity supply industry (DMRE, 2022b). It further aligns with international best practices by stipulating functions for a Transmission System Operator and a licencing framework for power generation, transmission, distribution and trading. In July 2023, NERSA approved the National Transmission Company of South Africa (SOC) licence to operate a transmission system in South Africa as a further step in Eskom's unbundling.

Since the first bid window in 2011, the Renewable Energy Independent Power Producer Procurement Program (REIPPPP) in South Africa has seen 88 renewable energy projects become operational, with three projects currently under construction and one that must reach financial close. The most recent bid window, Window 6, opened on 3 October 2022 and received 56 bids, of which six projects were successful (DMRE, no date). Notably, the low success rate of awarding preferred bidders can be largely attributed to the constraints in grid capacity to absorb additional renewable electricity generation. For instance, in Bid Window 6, no wind projects could be considered for approval as a result of no grid availability in the Western Cape, Eastern Cape and Northern Cape – where wind bid responses were located (DMRE, 2022a).

The success of the REIPPP has been remarkable in terms of attracting significant investment over a relatively short time period (Eberhard, Kolker and Leigland, 2014). To date, the REIPPPP has allocated over 6,000 MW of generation capacity to successful bidders across a range of renewable energy technologies, including grid-connected wind, PV, and concentrated solar. Other smaller technologies, such as hydro, landfill gas, and biomass energy, have also been included (DMRE, no date). Moreover, the REIPPPP has significantly impacted job creation in South Africa. For example, in the Eastern Cape alone, the 16 wind farms and one solar farm have generated 18,132 jobs, demonstrating the program's potential to create sustainable employment opportunities (RSA, no date).

In August 2020, South Africa launched the 2,000 MW Risk Mitigation IPP procurement programme (RMIPPPP), which is a technology-agnostic and output-based tender aiming to address a critical power supply gap and reduce the use of diesel peaking plants (DMRE, 2020d). The requirements for

the technologies are that they must be flexible, dispatchable, generate between specified hours, meet the required minimum load factor, and provide selected ancillary services. This includes co-located renewables plus storage technologies (DMRE, 2020d).

In July 2023, the DMRE released the South African Renewable Energy Masterplan (SAREM) for stakeholder comment (DMRE, 2023). The Masterplan aims to stimulate the industrial and inclusive development of value chains for renewable energy and battery storage (Smith, 2023). The SAREM supports and aligns with the Energy Action Plan and has four key pillars:

- "Supporting the local demand for renewable energy and storage by unlocking market demand and system readiness;
- Driving industrial development by building renewable energy and storage value chains, through localisation drives on both the public and private sector markets and supportive trade and industrial policy;
- Fostering inclusive development of renewable energy and battery storage, by driving the transformation of the industry, supporting the development of emerging suppliers, and contributing to a just transition; and
- Building local capabilities in terms of skills and technological innovation." (DMRE, 2023).

Along with renewables, the Government has identified natural gas as potentially transforming the South African energy sector. As gas is less emissions intensive than coal, it represents a mitigation opportunity. According to the IRP 2019, the country's goal is to increase the contribution of natural gas in the country's energy mix from 2.6% to 15.7% by 2030 (DoE, 2019). It is expected that the increased use of natural gas will help address the country's energy challenges, including electricity shortages and high electricity costs, and provide a flexible and efficient energy source to meet the country's energy needs. To achieve this goal, the Government has outlined several measures, including developing new natural gas infrastructure, promoting the use of LNG, and encouraging private investment in natural gas projects.

Existing efforts by the Government for the adoption of gas to power include the design of a Gas IPP procurement programme and the issue of a procurement schedule for 3,000 MW of gas-fired power plants by the IPP Office (DoE, 2019). These actions align with the Ministerial Determination and are the total gas generation allocated under the IRP up to 2027 (Lumley, 2022).

In December 2019, the Draft Upstream Petroleum Resources Development Bill was released, which came a month after President Cyril Ramaphosa announced the South African Government's plan to enhance policy certainty and foster a stable investment environment for the oil and gas industry in South Africa (RSA, 2021a). Presently, the Mineral and Petroleum Resources Development Act, 2002 (MPRDA) governs the exploration and production of oil and gas. The Bill aims to nullify and replace the pertinent sections of the MPRDA that relate to upstream petroleum operations (Norton Rose Fulbright, 2020; RSA, 2021a).

South Africa's Gas Master Plan, once developed, will serve as a policy instrument that will act as a roadmap for taking strategic decisions to guide investment planning and coordinate implementation (TAB, 2021). The Department of Mineral Resources and Energy (DMRE) released the Gas Master Plan Base case report for public comment in 2021 (Pombo-van-Zyl, 2022). The base case report presents baseline information on the natural gas sector in South Africa and outlines the roadmap for the Gas Master Plan (DMRE, 2022d). The IRP also notes that the Gas Master Plan for the SADC region must be developed and completed before the Gas-to-Power programme can be fully implemented in South Africa (DoE, 2019; Mkhize and Nel-Sanders, 2023).

The key policy related to energy efficiency in South Africa is the Draft Post-2015 National Energy Efficiency Strategy (NEES). This strategy builds on the efforts and achievements of the first National Energy Efficiency Strategy, released by the DoE in 2005. The NEES derived its mandate from the

White Paper on Energy Policy 1998 and set out targets and measures for energy efficiency improvements across various sectors. The initial NEES was developed in response to increasing energy demand alongside the country's commitment to sustainable resource use and reducing the national environmental footprint (DoE, 2016a). The NEES was subsequently revised in 2011, and in 2012, a National Energy Efficiency Action Plan was developed to guide the implementation of the strategy. In 2014, with the establishment of the Energy Efficiency Target Monitoring System, results indicated that significant progress was made between 2000 and 2012 in improving energy intensity, exceeding targets set for most sectors (DoE, 2016a).

The Draft Post-2015 NEES aims to build and improve on these achievements through fiscal and financial incentives, a sound legal and regulatory framework and enabling measures (DoE, 2016a). The purpose of the Post-2015 NEES is to "promote energy efficiency as the 'first fuel' in driving balanced, socially inclusive and environmentally sustainable economic growth, boosting job creation and leading technological innovation across the region" (DoE, 2016a).

There are a number of policies and measures in place to address energy use in commercial and residential buildings and reduce associated emissions. One of the key pieces of legislation for the sector is the National Building Regulations and Buildings Standards Act. In 2011, the then Minister of Trade and Industry added sections related to environmental sustainability and energy usage in buildings (Swift, 2013). The motivation behind this amendment was to reduce the GHG emissions caused by structures through energy consumption and associated emissions of new commercial and residential buildings. At the same time, The South African National Building Standards: SANS 10400-XA, was adopted and stipulates the minimum requirements of the South African National Building Regulations on energy efficiency and environmental sustainability in building design. The SANS 10400-XA standard has been developed to focus on energy efficiency (USAID, 2020). In 2020, the DMRE published regulations for the mandatory display and submission of energy performance certificates for buildings (DMRE, 2020b).

The Draft Post-2015 NEES (National Energy Efficiency Strategy) emphasizes adopting appropriate standards, appliance labelling, awareness, and education as critical approaches to achieving the reduction target (DoE, 2016a). The NEES identified the following targets for the commercial sector (DoE, 2016a):

- A 37% reduction in the specific energy consumption (measured as GJ annual energy consumption per m^2 of lettable / habitable floor area) by 2030 relative to a 2015 baseline.

The NEES further identified the following targets for the residential sector (DoE, 2016a):

- 33% reduction in the average specific energy consumption of new household appliances purchased, and
- 20% improvement in the average energy performance of the residential building stock.

The Energy Efficiency Standards and Appliances Labelling (S&L) Programme, aims to improve energy efficiency and reduce energy demand, and derives its legal basis from Section 19-I of the National Energy Act 34 of 2008. This section relates to product labelling for energy efficiency purposes and energy efficiency standards for specific appliances (DoE, 2017). The primary objective of the S&L Project is to remove inefficient household appliances and promote the use of energy-efficient alternatives through mandatory Minimum Energy Performance Standards (MEPS) and a product labelling system. The MEPS sets the minimum energy levels required for listed products and prohibits the market entry of appliances that do not meet the minimum energy performance standards. The product labelling system is designed to provide end-users with information on the energy consumption levels of various products.

Section 12L of the Income Tax Act (Act no. 58 of 1962) provides environmental incentives or allowances for energy efficiency savings and enables businesses to claim a tax deduction for efficient

energy use and investments in energy-efficient technologies (Eskom, 2021). The deduction or incentive rate is 95 cents per kilowatt hour for the difference between the energy the entity uses and the energy it would use if it had not installed the energy-efficient technology (Eskom, 2021). The tax allowance under Section 12L applies to all industries and economic sectors for a consecutive 12-month period, after which companies can claim the incentive retrospectively on 12 months' actual energy savings. Since its inception in 2013, it has delivered more than 24 terawatt-hours (TWh) in energy savings (by 2020). The mining and manufacturing subsectors have been significant beneficiaries of Section 12L since its inception, and approximately 5.9 gigawatt-hours (GWh) of energy savings have been realised (by 2020) (RSA, 2020). As proposed in the 2022 Budget, the energy efficiency savings tax incentive is to be extended for an additional 3-years, from January 2023 to December 2025 (NT, 2022d).

3.3.3 Transport

According to South Africa's 8th National GHG Inventory, transport was responsible for **48,193 $GgCO_2eq$** in 2020. This is **12.7 %** of energy related emissions GHG emissions, with road transport accounting for 93%, mainly from the combustion of petrol and diesel (DFFE, 2022b). Other sources of emissions, include civil aviation, railways and water-borne navigation. Emissions from this sector are likely to increase as the 2020 inventory showed a decline in road transport emissions due to the impact of reduced travel as a result of COVID-19 restrictions (DFFE, 2022b).

As the majority of emissions are related to road transport, policies and measures related to mitigation in this sector tend to focus on both passenger and freight road transport. The key policies and measures related to climate change mitigation are presented in Figure 3-9 and discussed further below.

Figure 3-9: Key policies and measures relevant to transport.

The National Land Transport Act 5 of 2009 (NLTA) is the key policy that sets the overarching goals, vision, and objectives for the transport system. The Act outlines the responsibilities for all spheres of government in terms of transport planning and places increased responsibilities on provincial and

municipal authorities to effectively implement land transport policy and strategy (RSA, 2009b). In 2016, the National Land Transport Amendment Bill was developed to provide for the inclusion of non-motorised and accessible transport, as well as to provide for developments to the implementation of the Act (RSA, 2016). In the same year, The National Transport Master Plan 2050 was approved by cabinet. It contains a strong stated commitment towards reducing greenhouse gas emissions in the transport sector (DoT, 2016). Most recently, the Revised White Paper on National Transport Policy has been published (DoT, 2022a). The Revised White Paper contains the vision, policy objectives and principles underpinning the country's national transport policy. Environmental objectives and climate mitigation imperatives come through strongly in the White Paper, which also talks to incorporating the "avoid-shift-improve" paradigm into transport policy (DoT, 2022a).

The National Land Transport Strategic Framework (2023-2028), is a requirement of the NLTA and outlines the national 5-year transport strategy to guide transport planning and land transport delivery at the national level; Provincial Land Transport Frameworks and Municipal Integrated Transport Plans.(DoT, 2023). The Green Transport Strategy (GTS) is the Department of Transport's key policy related to climate mitigation in the sector (DoT, 2018). The overall stated mitigation target expressed in the GTS is to reduce GHG emissions and other environmental impacts from transportation by 5% in 2050 (DoT, 2018). The objectives of the GTS that relate directly to climate change mitigation include to:

- Enable the transport sector to contribute its fair share to the national effort to mitigate climate change;
- Promote the development of the efficient integrated transport systems to enable sustainable socio-economic development;
- Provide information and raise awareness to promote behavioural changes towards lower carbon transport modes;
- Contribute to the low carbon transition of the sector, by aligning and developing policies which promote energy efficiency and emission reductions.

While the DoT can and has developed policy and undertaken various initiatives to improve fuel efficiency, promote the uptake of alternative vehicle technologies and a shift to more sustainable transport modes, there is a recognition across the policy documents of the role of land use planning in reducing urban sprawl to support a low carbon transition in the transport sector.

The GTS contains a short-term aim is to convert 5 % of the public and national sector fleet to green cleaner alternative fuel vehicles, including the use of compressed natural gas (CNG), biogas and biofuels, and renewable energy to drive electric vehicles (NAAMSA, 2023). The Biofuels Industrial Strategy (BIS) was introduced in 2005 and approved by Cabinet in December 2007, setting the stage for a national biofuels programme (DME, 2007; WWF, 2020). The approval of the BIS foresaw a pilot phase from 2008 to 2013 and involved a 2 % penetration target of biofuels in the national transport fuels, petrol and diesel (DMRE, 2020c). However, adequate regulations were needed to implement the BIS, which came about in the form of the Biofuels Regulatory Framework (WWF, 2020). The Biofuels Regulatory Framework provides for mandatory blending requirements for petrol and diesel of between 2-10% v/v bioethanol and 5% v/v biodiesel (DMRE, 2020c). While the legislation has been gazetted, there is still uncertainty regarding its implementation with the result that the private sector is not investing in biofuels production (DoT, 2023).

The DoT has also developed policy that relates specifically to rail and non-motorised transport. The recently published White Paper on the National Rail Policy, recognises the role for rail in decarbonising the transport sector, but also that there is scope to further reduce emissions associated with rail (DoT, 2022b). The White Paper aims to develop a decarbonisation strategy for the rail sector and undertake consultation to ensure that rail maximises its contribution to South Africa's mitigation targets (DoT, 2022b). The Draft National Non-Motorised Transport (NMT) Policy 2008 also has a climate mitigation outcome and is intended to formalise NMT in the country's integrated transport

system while also addressing the challenges of accessibility to transport (DoT, 2008). The policy encourages alternative transport modes such as cycling, walking and animal-drawn transport.

Overarching climate change policy also has a bearing on the transport sector. The Carbon Tax Act (Act 15 of 2019) includes a carbon fuel levy, which follows the carbon tax rate. In 2023, the carbon fuel tax levy was stipulated at a ZAR 10c per litre for petrol, and ZAR 11c per litre for diesel (RSA, 2019a; NT, 2022b). New passenger vehicles are also subject to an environmental levy related to their emissions intensity, which increases in line with carbon tax increases (NT, 2022c). The Draft Post-2015 NEES contains a 20% reduction target for the average vehicle energy intensity (measured in MJ/km) of the South African road vehicle fleet by 2030 (relative to a 2015 baseline) (DoE, 2016a).

3.3.4 Industrial Processes and Product Use (IPPU)

Industrial Processes and Product Use (IPPU) emissions are non-energy related emissions arising from industrial processes. IPPU emissions in 2020 were **25,486** Gg CO_2eq, which represents 5.4% of national emissions (excluding FOLU) in that year (DFFE, 2022b). The largest source of IPPU emissions is the metals industry (iron and steel and ferro-alloys), which together account for **48%** of emissions, followed by the minerals industry and the products used as substitutes for ozone depleting substances both contributing approximately **20%** each (DFFE, 2022b).

The key policies related to industrial development and climate change mitigation in this sector are presented in Figure 3-10 and discussed further below.

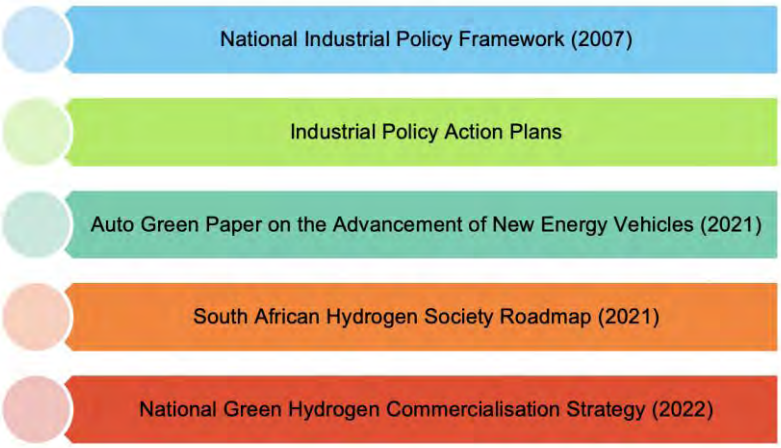

Figure 3-10: Key policies impacting mitigation in industry

The National Industrial Policy Framework (NIPF) of 2007 has guided the development and the implementation of industrial policy in South Africa (DTI, 2007). This framework forms the basis for the Industrial Policy Action Plan (DTI, 2018). Notably, while the IPAP implementation plan itself is short term, updates to the Plan are provided regularly, thus allowing for continuous improvements and refinement of various programmes in reaching set targets.

The most recent revision of IPAP (2018/2019 – 2020/2021) provides an update on one of the critical areas within the development sphere of the industrial sector, the Green Industry Action Programme. The Green Industry Action Programme aims to contribute directly to our national climate mitigation efforts in the short term in some of the following ways (RSA, 2020):

- The development of a Policy Roadmap for Climate-Compatible Industrial Development
- Systemised resource efficiency data collection and reporting
- The industrial water efficiency project (mitigation benefit through energy savings associated with water supply)

- The Industrial Energy Efficiency Project
- Resource-efficient and cleaner production skills development
- Specialist skills development in resource-efficiency and cleaner production

The DTIC further provides incentives such as the Manufacturing Competitiveness Enhancement Programme and Production Incentive to encourage industries to achieve their energy savings targets (DTI, 2017, 2018).

Two key growth sectors are worth discussing in more detail as they have a direct bearing on the low emissions development pathway of South Africa, namely New Energy Vehicles and the development of a green hydrogen industry.

The Auto Green Paper on the Advancement of New Energy Vehicles is a long-term strategy released by the DTIC in May 2021 (DTIC, 2021). The Green Paper aims to position South Africa at the forefront of manufacturing new energy vehicles and vehicle components (DoT, 2018). As well as positioning South Africa as a leader in electric vehicle production, local production would likely accelerate South Africa's transition towards cleaner fuel technologies.

Similarly, the green hydrogen industry could become a game changer in South Africa's aspirations to move towards a net-zero carbon economy. The South African government has expressed its commitment to the development of a green hydrogen economy in the country, as outlined in the IRP 2019. The IRP identified green hydrogen as a key technology for South Africa's energy transition, with potential applications in sectors such as transport, industry, and power generation. The IRP set a target of 3.8 GW of electrolysis capacity to produce hydrogen by 2030. The JET Framework and associated JET-IP also focus on the development of a green hydrogen industry (PCC, 2022, RSA, 2022d).

In 2021, the Department of Higher Education, Science, and Innovation launched the South African Hydrogen Society Roadmap (HSRM) (DSI, 2021). The HSRM is a comprehensive plan to develop a hydrogen economy in South Africa and aims to create a favourable regulatory environment for the adoption of hydrogen energy in the country. The roadmap looks to position South Africa as a leader in the global hydrogen economy by 2050 through the following outcomes:

- "Decarbonisation of heavy-duty transport;
- Decarbonisation of energy-intensive industry (cement, steel, mining, refineries);
- Enhanced and green power sector (main and micro-grids);
- Centre of Excellence in Manufacturing for hydrogen products and fuel cell components;
- Creating an export market for South African green hydrogen; and
- Increasing the role of hydrogen (grey, blue, turquoise and green) in the South African energy system in line with the move towards a net-zero economy" (DSI, 2021).

Further support for realising the HSRM is found in the National Green Hydrogen Commercialisation Strategy, which aims to give confidence to investors that South Africa is a destination for investment in the Hydrogen Economy (DTIC, 2022). Realising the outcomes of the HSRM is contingent upon addressing the existing human capacity and sector skills gap in South Africa. To this end, in February 2022, the Minister of Higher Education, Science, and Innovation launched the South African Green Hydrogen Technical Vocational and Educational Training (TVET) Ecosystem Just Transition Framework. This framework aims to support the emerging hydrogen economy and rapid expansion of renewable energy production and employment in the green economy (DSI, 2022).

Although the focus of recent policy discourse, South Africa has been considering its participation in the hydrogen economy for some time. The Hydrogen South Africa (HySA) SA Programme was initiated by the Department of Science and Technology (DST) and approved by the Cabinet in May 2007. This long-term (15-year) programme within the department's Research, Development, and Innovation (RDI)

strategy aimed to achieve a 25% share of the global Hydrogen and Fuel Cell market using novel PGM catalysts, components and systems (HySA Systems, 2007). Three Centres of Competence were established through the collaboration with R&D institutions and industry partners: HySA Catalysis (University of Cape Town and Mintek); HySA Systems (University of the Western Cape); and HySA Infrastructure (North West University, and the Council for Scientific and Industrial Research).

3.3.5 Agriculture, Forestry and Land Use (AFOLU)

The AFOLU sector includes both sources and sinks of GHG emission. When sinks from forestry and land use are excluded, it is the second largest contributor to emissions accounting for **40,775 $GgCO_2eq$** or **8.7%** of the gross emissions in 2020 (DFFE, 2022b). The Livestock sector contributed **77%** to total AFOLU emissions (excluding FOLU), which is mainly attributed to enteric fermentation. Aggregate sources and non-CO_2 emissions sources accounted for a further **23%** of emissions with over half of this coming from direct N_2O emissions from managed soils. For the land category, forest land is the largest contributor to the sink, followed by grasslands. Other Land is the main CO_2 source in the land category.

Agriculture and forestry are widely recognised as sectors that have significant job creation, and together with land use have a role to play in South Africa achieving low carbon development. The main recent policies and measures impacting AFOLU are presented in the figure below followed by a discussion.

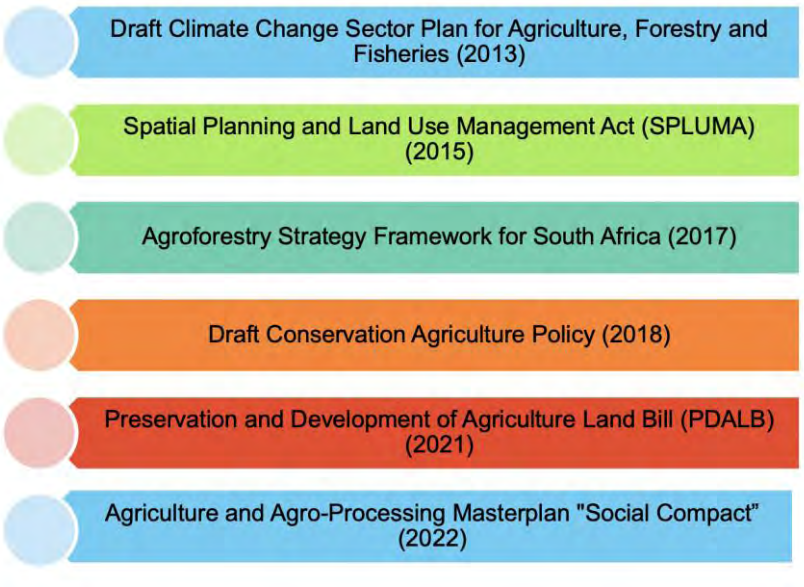

Figure 3-11: Key policies and measures related to AFOLU

A draft Climate Change Sector Plan for the Agriculture, Forestry and Fisheries sector was published in 2013 (DAFF, 2013). The Plan was developed to address institutional arrangements, vulnerability assessments and identify mitigation and adaptation responses. Similarly, the Agroforestry Strategy Framework for South Africa, 2017, recognises the role of agroforestry systems in climate change mitigation through carbon sequestration in soils, while also contributing to climate change adaptation by supporting diversified and resilient land use practices (DAFF, 2017a).

Conservation agriculture (CA) is recognised as a practical and cost-effective production system that addresses sustainability concerns, particularly considering climate change mitigation and adaptation (Midgley et al., 2015). Although commercial farmers in South Africa are increasingly adopting CA practices, there are still various knowledge, cultural, social, and legislative barriers hindering full adoption. South Africa's draft Conservation Agriculture Policy was released for stakeholder comment in 2018 and aims to tackle the pressing need for adapting traditional farming systems, which are causing a decline in agricultural output and leading to significant deterioration of natural resources

(DAFF, 2017b). The Agricultural Policy Action Plan (APAP) also promotes both conservation agriculture as well as Climate Smart Agriculture (CSA), which is a broader term that encompasses practices that sustainably increase productivity, reduce GHG emissions, adapt to climate change and minimise vulnerability (DAFF, 2015).

Although not directly related to climate change mitigation, the Spatial Planning and Land Use Management Act (SPLUMA) was passed by Parliament in 2013 and came into effect on 1 July 2015. SPLUMA aims to develop a new framework to govern planning permissions and approvals, confirm and regulate the role of municipalities in land-use planning and management, sets parameters for new developments, and provides for different lawful land uses in South Africa, thus impacting land use and land use change. In the context of climate change mitigation, the SPLUMA also becomes relevant in the planning process which must be followed to establish land use rights for the development of Renewable Energy projects.

The Subdivision of Agricultural Land Act, Act 70 of 1970 (SALA), the law governing agricultural land subdivision, puts tight restrictions in place for the subdivision of agricultural land. This is particularly relevant in the renewable energy sector, where renewable energy projects like wind and solar projects are often constructed on agricultural land. Lengthy approval processes can have a negative effect on South Africa's climate change mitigation efforts. To address this, the Preservation and Development of Agriculture Land Bill (PDALB) was introduced in 2021 (RSA, 2021b). The PDALB aims to introduce transitional arrangements for phasing out SALA whilst ensuring the protection of agricultural land (Fasken, 2021).

The Agriculture and Agro-Processing Masterplan (AAMP) "Social Compact", 2022, is one of the seven plans that was introduced by President Ramaphosa at the State of the Nation Address in 2019 as essential for the economic reconstruction and recovery of the country (NAMC, 2022). One of the objectives of the AAMP is to foster globally competitive agricultural and agro-processing sectors, and implement technological innovations, infrastructure development and digitalisation, which would contribute to climate change mitigation in the sector (DALRRD, 2022).

In 2015, South Africa started working on the National Reduction of Emissions from Deforestation and Forest Degradation (REDD+) Programme, with the formation of an Informal REDD+ Consultative Task Team (IRCTT). The IRCTT was tasked with developing a REDD+ strategy that would be aligned with the country's broader development objectives and national climate change policy (Knowles et al., 2020b).

The IRCTT conducted an analysis of the drivers of deforestation and forest degradation in the country, as well as the potential for reducing emissions from the forestry sector, which led to the commissioning of the South African REDD+ Readiness Study (Knowles et al., 2020a). While South Africa is still in the early stages of developing its National REDD+ Program, there have been several REDD+ projects implemented in the country. These projects are designed to reduce GHG emissions by avoiding deforestation and forest degradation. As the country continues to develop its National REDD+ Program, it is likely that more projects will be implemented to reduce GHG emissions and promote sustainable land use.

Various "Working for Programmes" have been initiated by the DFFE, informed by the broader Expanded Public Works Programme. These projects present an opportunity to contribute significantly to job creation, social inclusion and the low-carbon green economy. The "Working for Programme" projects include:

- Working for Forest programme: promotes the sustainable development and management of new afforestation, transforming invading alien plant stands and degraded state forests.
- Working for Ecosystems programme: aims to reverse environmental degradation through ecological restoration and maintenance programmes, thereby enhancing ecosystem services such as carbon sequestration.
- Working for the Coast programme: helps protect and conserve the coastal environment.

- Working for Water programme: aims to reduce the density of established, terrestrial, invasive alien plants, through labour intensive, mechanical and chemical control.
- Working for Land programme: seeks to address degradation of land due to desertification, overgrazing, soil erosion, poor storm water management and unsustainable farming practices.
- Working for Wetlands programme: focuses on the rehabilitation, wise use and protection of wetlands in a manner that maximises job creation.
- Working on Fire programme: is a government-funded, job-creation programme focusing on Integrated Fire Management in South Africa.
- Working on Waste programme: seeks to ensure that both social and ecological sustainability is achieved through the implementation of sustainable waste management practices.

3.3.6 Waste

Emissions from the waste sector were an estimated **23,046 $GgCO_2eq$** in 2020 and contributed approximately 5% to total emissions in 2020 (DFFE, 2022b). Almost 80% of these emissions are attributable to methane emissions from landfilled waste (solid waste disposal), followed by wastewater treatment and discharge, with a minor contribution (less than 2%) from the incineration and open burning of waste. Waste emissions have increased steadily from 2020, reflecting their relationship with population growth and increased consumption.

The key polices and measures related to mitigation in the waste sector are shown in Figure 3-12 and discussed further below.

Figure 3-12: Key policies and measures relevant to waste

The White Paper on Integrated Pollution and Waste Management forms the basis for pollution and waste management in South Africa, where the overarching objective is to move from a previous situation of fragmented and uncoordinated pollution control and waste management to integrated pollution and waste management, with particular attention to waste minimisation (DEAT and DWAF, 1998).

The National Environmental Management Waste Act (No 59 of 2008) forms the overarching regulation that governs waste management in South Africa. The act seeks to regulate waste management to protect health and the environment as well as provide measures to prevent pollution and ecological

degradation and secure ecologically sustainable development. The key governing principle in the act is the waste hierarchy, which favours waste minimisation, reuse, recycling and recovery over that of disposal (RSA, 2009a).

The National Policy on Thermal Treatments of General and Hazardous Waste, 2009 provides for thermal waste treatment to be included in the country's waste management system to provide environmentally sound waste management practices, particularly for hazardous waste (DEA, 2009).

The National Waste Management Strategy (NWMS) 2020 is an update to the previous NWMS that was developed in 2011. The 2020 strategy builds on the 2011 strategy by including the concept of "circular economy" and setting out a comprehensive framework for waste management, with a focus on waste minimisation, resource recovery, and the safe disposal of waste (DFFE, 2020b).

The NWMS further assimilates the government's strategic approach to waste management with the commitments and directives of the Sustainable Development Goals 2030 and South Africa's NDP Vision 2030. The NWMS 2020 identifies four key objectives for achieving sustainable waste management in South Africa (DFFE, 2020b):

- Reduce the amount of waste generated: The strategy aims to promote waste minimisation by encouraging producers and consumers to adopt sustainable production and consumption practices.
- Increase resource recovery: This includes the development of new recycling technologies and the promotion of waste-to-energy systems.
- Promote safe disposal of waste: This includes the development of new landfill technologies.
- Build capacity for sustainable waste management.

The Municipal Waste Sector Plan, 2012, addresses waste service delivery at local government level, highlighting reuse and recycling and reducing landfill emissions by recovery of landfill gas or flaring (DEA, 2012b). Supporting this is the Municipal Solid Waste Tariff Strategy, 2012, which provides guidance for municipalities to set solid waste tariffs that align with the NWMS intentions (DEA, 2012a). The strategy aim to include a full cost accounting approach for financial sustainability and efficient waste services. (DEA, 2012a)

The NWMS promotes composting as one of the approaches towards achieving the objectives of the waste management hierarchy. The National Organic Waste Composting Strategy (NOWCS) of 2013 was initiated with the aim to develop and promote the diversion of organic waste from landfill sites for soil beneficiation and other uses through composting. The strategy made several recommendations, which included amongst others, the development of norms and standards for organic waste compost, to provide for a national approach to composting and to exempt composting facilities from requiring a Waste Management Licence (DFFE, 2013).

A key amendment to the National Environment Management Waste Act (59 of 2008) that has been implemented relates to Extended Producer Responsibility (EPR) (DFFE, 2021a). EPR ensures that producers are responsible for their products across their full life cycle, which encompasses design, production and end-of-life. This is consistent with the "Polluter Pays" principle (DFFE, 2023a). The regulations affect the electrical and electronic equipment sector, the lighting sector, and paper, packaging and some single use products. The amended regulations require producers to register on the South African Waste Information Centre (SAWIC) website as well as to establish and implement extended producer responsibility schemes (DFFE, 2021a).

3.4 Climate Change Mitigation Barriers and Capacity Needs

South Africa faces deep challenges related to poverty, inequality and unemployment, often referred to as South Africa's "triple challenges". These challenges are not only exacerbated by climate change

but may be intensified by the rapid changes required for low carbon development. The JET Framework identifies three policy areas to address the challenges of the Just Transition, including:

- Human resource development and skills development
- Industrial development, economic diversification, and innovation
- Social protection measures.

In addition, South Africa's NDP 2030 as well as the Climate Change Bill calls for a Just Transition towards a low carbon economy, in such a way that does not impede socio-economic development, is socially just, and leads to sustainable job creation. Given the confluence of various factors; the aging of the country's coal power plants, the cost competitiveness of renewable technologies, our vulnerability to climate change and the slow growth since the Covid-19 pandemic, South Africa offers a unique opportunity to investors to finance the country's decarbonisation efforts (Rambharos, 2021).

The Just Energy Transition Investment Plan (JET-IP) outlines investments in three priority sectors (RSA, 2022c):

- Energy Sector: Decommissioning ageing power stations and repurposing it with clean technologies, transmitter grid strengthening and expansion, and renewable energy.
- New Energy Vehicles (NEV): Decarbonising the automotive sector and supporting supply chain transition towards green sustainable manufacturing.
- Green Hydrogen: Essential planning and feasibility studies including investments in ports to enhance exports and boost employment and GDP.
- Cross-cutting investments in skills development and municipalities.

The investment criteria in these sectors include projects that deliver on GHG emission reduction, are catalytic in nature and which are underpinned by the values of the Just Transition, to ensure that those who are most affected by the transition from coal, are not left behind. There are various estimates in terms of the magnitude of investment required. According to an International Finance Corporation study, achieving South Africa's NDC would require a total investment of ZAR 8,9 trillion over 15 years (from 2015 to 2030), equating to an annual investment of ZAR 596 billion to achieve South Africa's NDC by 2030 (Cassim et al., 2021). The JET-IP estimates that South Africa will require ZAR 1.48 trillion over the next five years. The breakdown of these costs according to the priority sectors and spend areas is provided in the table below:

Table 3-3: Financing needs of the Just Energy Transition Investment Plan (2023 – 2027) (RSA, 2022c)

ZAR billions	Electricity	NEV	Green Hydrogen	Subtotal
Infrastructure	978	83	313	1,374
Planning and implementation capacity	2.14	2	5.5	9.9
Economic diversification and innovation	40.4	43	-	83.4
Social investment and inclusion	9.6	-	-	9.6
Skills development			2.7	2.7
Subtotal	1,030.4	128	319	
TOTAL				1,480

This scale of investment will need to be secured from both the public and private sectors or blended finance. Blended finance is a financial approach that combines public and private sector resources to finance projects aimed at achieving development goals, including climate mitigation and adaptation. South Africa has implemented a blended finance facility, in partnership with the South African Government, the Green Climate Fund and the DBSA. The Climate Finance Facility launched in February 2019, has a lifespan of 20 years with a 5-year implementation period. The facility "aims to incentivise private investment in low-carbon and climate-resilient infrastructure and catalyse greater overall climate-related investments in the four Rand-based economies in the Southern-African region, including South Africa, Namibia, Lesotho, and eSwatini" (Convergence, 2019).

The Climate Finance Facility mobilises the private sector to support South Africa's mitigation efforts using innovative financial instruments such as guarantees, concessional loans and equity investments. The facility provides financing to projects in the renewable energy, energy efficiency, and sustainable transportation sectors. In addition to providing financial support, the Climate Finance Facility also offers technical assistance to project developers to improve their investment readiness, project design, and financial structuring. The facility also works to build capacity in the South African financial sector to mobilise private sector financing for climate mitigation efforts. The Climate Finance Facility is expected to leverage up to ZAR 4.2 billion in private sector investment to support South Africa's transition to a low-carbon economy (Convergence, 2019).

As well as investment and new skills development, it is important to protect those groups of workers whose livelihoods may be impacted by climate change or the transition to a lower carbon economy. The National Climate Change Response White Paper therefore requires the development of Sector Jobs Resilience Plans (SJRPs). South Africa's SJRPs are a key part of the country's efforts to address the challenges posed by climate change while promoting economic growth and job creation. These plans aim to support the development of a low-carbon economy by identifying opportunities for investment and job creation in sectors such as renewable energy, sustainable agriculture, and green infrastructure. The SJRPs have been informed by the National Employment Vulnerability Assessment (NEVA), which identified vulnerable sectors of the economy provided that were suitable for a programmatic response, and also identified the specific needs of the vulnerable groups in these sectors (Makgetla et al., 2019).

The following SJRPs have been developed as well as a SJRP Toolbox Summary for policy makers:

- Coal value chain SJRP (TIPS, 2020b)
- Metals value chain SJRP (TIPS, 2020c)
- Petroleum-based transport value chain SJRP (TIPS, 2020d)
- Agriculture value chain SJRP (TIPS, 2020a)
- Tourism value chain SJRP (TIPS, 2020e)

South Africa's Economic Reconstruction and Recovery Plan, introduced by President Cyril Ramaphosa in October 2020, outlines further interventions and reforms that will contribute to South Africa achieving its goals of low carbon development, job creation and poverty alleviation (The Presidency, 2020, 2023a). These include regulatory reforms to enable growth and investment, addressing corruption and strengthening the capacity of the State to plan and implement the required policy (The Presidency, 2020). Green industrialisation is identified as a key element of the plan (The Presidency, 2023a). The Department of Higher Education and Training has published a Skills Strategy in support of the Plan, which outlines key interventions to address skill shortages (DHET, 2022).

3.5 Monitoring and Evaluation of Policies to Reduce GHGs

The NDP and NCCRP highlight the importance of monitoring the progress of South Africa's move towards a climate-resilient and low-carbon economy. To this end, both call for a mandatory national monitoring and evaluation and reporting system for climate change information (DEA, 2015b).

Following these policy mandates, South Africa's Monitoring and Evaluation (M&E) system has been in development since 2009, culminating with the publication of the National Climate Change Response M&E System Framework in 2015. The overall objective of the system is to track South Africa's transition to a climate-resilient society and a lower-carbon economy. Other cross-cutting objectives of the system include tracking climate finance to support the transition, and communication and learning. In order to support the effective tracking of transition to a lower-carbon economy and climate-resilient society the DFFE (formerly DEA) commissioned the development of a series of M&E guidelines (DEA, 2018). The first volume in the series focuses on policies, strategies and laws, particularly those that enable the effective tracking of monitoring of mitigation effects. Other volumes cover specific sectors (energy and transport, IPPU, waste and AFOLU).

The M&E system provides an evidence base on the impact of climate change in South Africa and informs the response to climate change, both in terms of scope and effectiveness of measures. The system also institutionalises and organises South Africa's periodic reporting obligations under the UNFCCC, including the transparency requirements of the new Paris Agreement on NDCs (DEA, 2016).

3.5.1 M&E System Framework Design

Based on the requirements of the NCCRP and the NDP, South Africa's climate monitoring system is composed of two primary complementary systems, shown in Figure 3-13:

1. The Climate Change Response M&E System
2. The GHG Inventory System

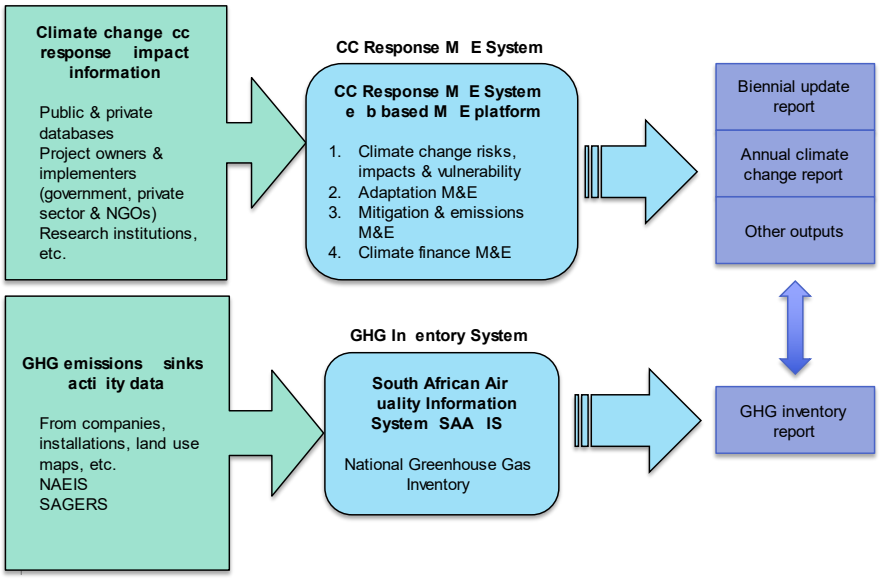

Figure 3-13: Summary of overall M&E system for climate change in South Africa (DEA, 2015b).

The Climate Change Response M&E System covers all other aspects of climate change M&E and uses the GHG Inventory as one of its primary information sources.

Based on the NCCRP's requirements, the system uses a tiered approach to track the transition to a lower carbon economy (DEA, 2016):

- Tier 1: Country-level
- Tier 2: Sectoral, sub-sectoral and company level
- Tier 3: Response measure level

The South African Climate Change Tracking Report is used to communicate the progress and lessons learnt in tracking South Africa's transition to a lower-carbon and climate-resilient economy (DFFE, 2023b). The Fourth South African Climate Tracking Report is the first to present mitigation indicators, an improvement for the Climate Change M&E System (DFFE, 2023b).

The GHG Inventory System, of which the main output is the GHG Inventory report, uses South African GHG Reporting System (SAGERS), an online platform for the submission of GHG emissions data per IPCC category, as its key source of activity data. SAGERS is the GHG Gas Reporting Module of the National Atmospheric Emissions Inventory System (NAEIS), an online platform for air quality and GHG emissions. The NAEIS forms part of the South African Air Quality Information System (SAAQIS). NAEIS was upgraded to include SAGERS as it was formerly aimed at air quality information.

3.5.2 Progression of South Africa's M&E system

South Africa's M&E System has been in development since 2009, starting with the development of the National Climate Change Response Database to track current climate change response programmes (DEA, 2015b). This was developed into a fully-fledged climate change response M&E system. The design of the M&E system was finalised in 2015 with the publication of the National Climate Change Response M&E System Framework document. Table 3-4 shows the progression of South Africa's M&E system since 2016, largely related to the update of the national GHG Inventory.

Table 3-4: Progression of South Africa's M&E system since 2016

Date	Description
2016	Development of the web-based Monitoring and Evaluation System. South Africa's 1st annual Climate Change Report is published. DFFE updates the national GHG Inventory (2000 – 2012). National GHG Emissions Reporting Regulations (NGERs) published.
2017	South Africa's 2nd Climate Change Report published
2018	DFFE updates the national GHG Inventory (2000 – 2013). Volume 1 of the Mitigation Monitoring and Evaluation Guidelines Series published. South Africa's 3rd Climate Change Report published.
2019	South Africa submits its Third Biennial Update Report.
2021	South Africa's updated NDC submitted. DFFE updates the national GHG Inventory (2000 – 2017).
2022	Climate Change Bill introduced to Parliament.
2023	DFFE updates the national GHG Inventory (2000 – 2020). The Fourth South African Climate Change Tracking Report

3.6 South Africa's Mitigation Status Quo

In 2020 South Africa's national net GHG emissions totalled **442,125 $GgCO_2eq$**, including the contribution from forestry and other land use (FOLU) (468 812 $GgCO_2e$ excluding FOLU) (DFFE, 2022b). The Energy sector accounts for 85.8% of the total emissions (including FOLU), an increase

from 83.3% in 2000. The IPPU and Waste sector account for 5.8% and 5.2% of net emissions respectively, with AFOLU emissions contributing 3.2%. Within the Energy sector, the Electricity subsector is the most significant contributor, accounting for almost half of the national net emissions in 2020. The transport sector, to a lesser extent, is also an important contributor to national emissions (11% of net emissions in 2020). The manufacturing and construction sector contributes to both energy (8%) and IPPU emissions (6%).

South Africa's updated NDC of 2021 shows increased ambition compared to the first NDC submitted in 2015. The updated NDC target for 2025 provides for lower and upper emission trajectory ranges from 398 to 510 $MtCO_2eq$, decreasing to a range of 350 to 420 $MtCO_2eq$ in 2030. Considering South Africa's net emissions in 2020 totalled 442 $MtCO_2eq$, South Africa is already in the range of the 2025 target, and only 22 $MtCO_2$ off the upper limit of the 2030 target. Net GHG emissions have decreased by almost 1% since 2000, peaking in 2009. This is largely attributed to a deteriorating economy coupled with the impact of COVID-19 and ongoing and prevalent load-shedding.

3.6.1 Energy Sector

South Africa's primary energy sources are dominated by coal (65%) and crude oil (18%) (DFFE, 2022b). Renewable and waste resources (11%), natural gas (3%) and nuclear (2%) make up the remainder of supply. CO_2 is the major GHG arising from South Africa's energy sector, largely from stationary combustion facilities such as power stations and refineries.

Considering the Energy sector is responsible for such a significant portion of emissions, this is a key sector to focus climate change mitigation efforts on. The Electricity and Heat Production subsectors contributed 47% of national emissions (including FOLU) in 2020 (DFFE, 2022b). This is predominantly on the account of coal-fired power stations which generate 79% of South Africa's electricity (total electricity available generated by Eskom and purchased electricity) (DFFE, 2022a). Eskom makes up the majority of generation in South Africa (88%), with a nominal capacity of 47,145 MW. Mitigation measures and technologies focusing on alternative low-carbon electricity generation are critical to the reduction of emissions in the electricity sector. These include renewable energy technologies such as solar PV and wind, coupled with storage solutions like batteries.

The transport sector is also an important contributor to national emissions due to the combustion of petrol, diesel, aviation gas and jet fuel, with the road transport sub-sector responsible for 93% of the fuel consumed in the transport sector in 2020 (DFFE, 2022b). Mitigation measures in the sector such as alternative fuels and power trains (e.g., CNG and hydrogen and hybrid, plug-in and electric vehicles) and modal shifts are important to consider.

The manufacturing sector contributes to both energy and IPPU emissions. Fuel consumption within the manufacturing sector is largely from coal (45.1%) with natural gas (20.5%), biomass (15.3%) and diesel (11.4%) as other important energy sources (DFFE, 2022b). Mitigation measures to reduce energy consumption and improve process efficiency are key to reducing emissions. Mitigation options in the manufacturing sector include:

- Technology substitution for example a switch to direct reduced iron in the iron and steel sector, converting to point-feeder pre-baked technology in the aluminium sector and replacing rotary kilns with vertical kilns or parallel flow regenerative kilns in the lime sector, among others.
- Energy efficiency measures such as energy management and monitoring systems, improved process control and heat exchange efficiencies, energy efficient electric motor systems and variable speed drivers.
- Fuel switch from coal, heavy fuel oil, petrol and diesel to natural gas, biomass, refinery fuel gas and/or biofuels.
- Production pathway switch from primary to secondary production.

- Alternative on-site power supply for example co-generation and waste heat recovery.

Carbon capture and storage (CCS) is also a potential technology option for emissions abatement in the power sector and industry. This is discussed in more detail in Section 3.7.2.

The residential and commercial/institutional sectors in South Africa are relatively small contributors to national emissions (1% each respectively). Most mitigation measures in this sector focus on reducing electricity demand (e.g., energy efficient appliances, variable speed drives and solar water heaters). In terms of energy emissions, fuel switching to LPG as well as electrification of households are potential abatement measures.

3.6.2 IPPU Sector

The IPPU sector contributed less than 6% of national emissions in 2020, mainly from the metals industry. Mitigation measures to reduce process emissions include technology substitution, fuel switches, production pathway shifts as well as sector-specific abatement technologies.

3.6.3 AFOLU

In 2020, the AFOLU sector including FOLU contributed 3% to national emissions. The livestock sector is the largest contributor to AFOLU emissions (31,372 $ktCO_2eq$), largely due to enteric fermentation. Feed changes, improved livestock efficiency and biogas digesters can reduce emissions from the livestock sector. The FOLU sector, mainly the Forest sub-sector, is a carbon sink (-27,322 $ktCO_2$) and the majority of mitigation measures in the AFOLU sector are focussed on this sector. This includes restoration of thickets, forests, woodlands and grasslands, afforestation (through commercial forestry) as well as the restoration and conservation of agricultural land. Carbon sinks and sequestration in the AFOLU sector are discussed in more detail in Section 3.7.1.

3.6.4 Waste

The waste sector contributed approximately 5% to total emissions in 2020. Abatement options in the sector are largely focussed on waste diversion/reduction though recycling and composting and electricity generation from landfill gas or energy from waste.

3.7 South Africa’s Carbon Sinks and Sequestration Potential

South Africa’s commitment to reducing GHG emissions and meeting its NDC mitigation targets encompasses different measures across sectors, including those that have the potential to sequester carbon. These include sequestration opportunities in the Forestry and Other Land use (FOLU) sectors as well as carbon capture and storage (CCS).

3.7.1 AFOLU – Carbon Sinks and Sequestration

In South Africa the AFOLU sector is reported to be a net source of GHG emissions in 2020 accounting 3.2% of total net emission (8.7% of total gross emissions). The sector is an important source of carbon sinks and sequestration potential in South Africa, with the Land sector acting as a carbon sink. Forest land is the largest contributor to the sink category in 2020 accounting for 67% of sequestration, with grasslands and settlements accounting for 30% and 3% respectively (DFFE, 2022b).

The NTCSA is the first of its kind for South Africa. It was developed with the aim of understanding the status and dynamics of terrestrial carbon stocks, potential climate change mitigation opportunities and supporting policy- and decision-making. The first NTCSA, published in 2014, has been improved upon, with the most recent NTCSA published in 2020 (referred to as NTCSA 2020).

In South Africa, most of the carbon in natural ecosystems is found in the soil (soil organic carbon), accounting for an estimated 89% of the total terrestrial carbon stock. The Savanah and Grassland

biomes contain the majority of this carbon (Figure 3-15 and Figure 3-15): grasslands and savannah, accounting for 36% and 31% of the total national carbon stock respectively (DFFE, 2020a). In terms of the geographical spread, total organic carbon is split relatively equally between the provinces with North West, Limpopo, Mpumalanga, KwaZulu Natal, Eastern Cape and the Free State reporting between 12% and 17% and the Northern Cape, Gauteng and Western Cape reporting between 2% and 7%.

The NTCSA 2014 identified nine potential mitigation opportunities in the sector (DEA, 2015a). These include restoration of sub-tropical thicket, forests and woodlands, restoration and management of grasslands, commercial small-grower afforestation among others, with emissions reductions potentially reaching 14 $MtCO_2eq$ per annum. Since soil carbon accounts for the vast majority of South Africa's carbon stocks, mitigation measures such as conservation agriculture, the use of soil amendment and biochar could be beneficial to both reducing GHG emissions and enhancing carbon stocks (DFFE, 2020a).

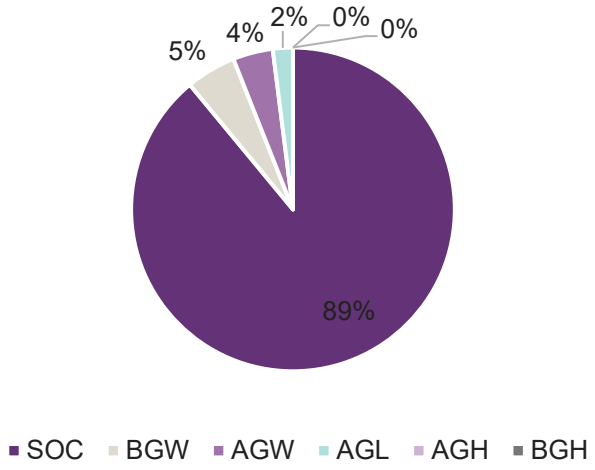

Figure 3-14: Organic carbon by carbon pool by biome5

[5] AGH: Above ground herbaceous biomass, AGL: Above ground litter, AGW: Above ground woody biomass, GBH: Below ground herbaceous biomass, BGW: Below ground woody biomass, and SOC: soil organic carbon.

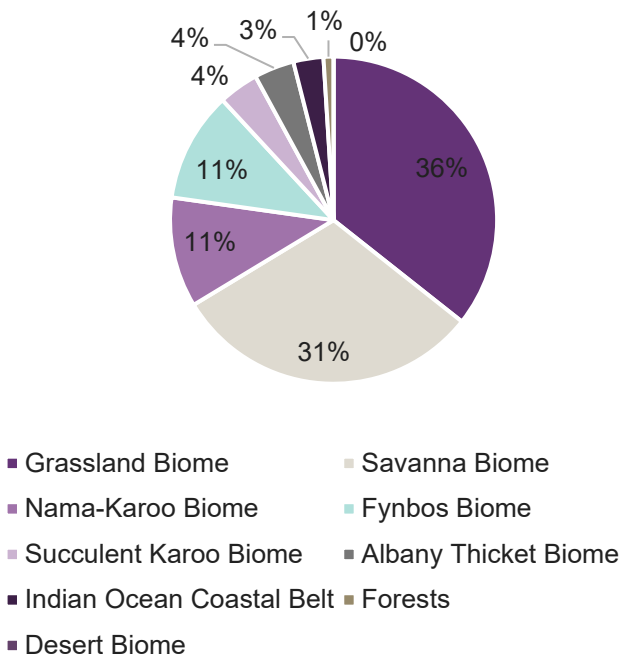

Figure 3-15 Organic carbon by total organic carbon by biome

3.7.2 Carbon Capture and Storage

CCS refers to a group of mitigation technologies which involves removing a concentrated stream of CO_2 from a source. The CO_2 is then compressed and transported to a storage location, typically a geological formation where to CO_2 is injected and trapped. CCS is well suited to mitigating large point sources of GHG emissions. It has proven technically feasible in a number of sectors globally with several facilities in operation or under development globally (Global CCS Institute, 2018).

The South African Centre for Carbon Capture and Storage (SACCCS), established in 2009, is a national flagship programme of the National Climate Change Response Strategy White Paper. SACCCs had an initial 5-year mandate to champion the development of CCS in South Africa. It formed part of a division in SANEDI before moving to the Council of Geosciences in 2020. The SACCCS is responsible for technical CCS research, development and capacity building in South Africa and includes the Pilot Carbon Dioxide Storage Project. The pilot project, based on Leandra Mpumalanga, aims to demonstrate the injection, storage and monitoring of 10 $ktCO_2$.

In 2010 SANEDI published the South Africa CCS roadmap (endorsed by Cabinet in 2012), which defined 5 key milestones to understand and develop CCS potential in the country (Beck, Surridge and Hietkamp, 2013):

- Assessment of the potential for CCS in South Africa.
- Development of a South African CO_2 geographical storage atlas.
- Commencement of the CO_2 Test Injection project.
- Facilitation of the commencement of a CCS demonstration plant (in the order of 100,000 tonnes CO_2 per year).
- Informing of the implementation of commercial CCS deployment.

Of the five milestones highlighted in the roadmap, two have been completed: assessment of potential of CCS in South African (2004) and the Atlas of geological storage of CO_2 (2010) (Beck, Surridge and Hietkamp, 2013). Geological mapping of South Africa's first CCS site commenced in 2021, in Leandra in Mpumalanga province, and aims to be operational by 2023 (Roelf, 2021).

3.8 South Africa's Projections to Mitigate Climate Change

The Long-Term Mitigation Scenarios (LTMS) study, commissioned by the DFFE (then Department of Environmental Affairs) and published in 2007, sought to build mitigation scenarios for South Africa. The "growth without constraints" emissions scenario and a "required by science" emissions scenario were used to inform South Africa's Peak-Plateau-Decline (PPD) emissions trajectory.

Following the LTMS, DFFE published the Mitigation Potential Analysis (MPA) in 2014, an updated bottom-up assessment of mitigation potential in key economic sectors (DEA, 2014). The process involved updating the projection of GHG and generating Marginal Abatement Cost Curves (MACCs) for key sectors and sub-sectors. In addition, a socio-economic and environmental assessment of the mitigation options was conducted in order to assess the wider macro-economic impacts of implementing the identified mitigation options. The MPA was modelled using Excel, however in order to facilitate future changes and additions to the model, there was a need to move the MPA into a user-friendly interface, Analytica. The MPA model in Analytica includes an economic model in the form of a social accounting matrix (SAM) to evaluate the socio-economic implications of mitigation options individually, for sectors and the economy as a whole. Additional socio-economic, environmental and implementability criteria for each mitigation option are included in the model as part of a multi-criteria assessment (MCA). The MPA contains three key scenarios:

- Without Measures (WOM) projection which assumes that no mitigation policies and measures have been implemented since 2000.
- With Existing Measures (WEM) projection, which incorporates the impacts of climate change mitigation policies and measures implemented to 2019.
- With Additional Measures (WAM) projection, which assumes that existing, pipeline and potential future climate change mitigation policies and measures are implemented.

The MPA has been updated since 2014, with the most recent update taking place in 2022 and serves as a valuable policy tool for government (Merven et al., 2021). Updates since 2014 include, but are not limited to:

- Updated Gross Domestic Product (GDP) projections and sectoral growth rates.
- Growth projections in the petroleum refining and coal mining sector are dependent on demand for petroleum products and coal in other sectors. To ensure the model is internally consistent, the demand is thus taken from the model rather than exogenous sources.
- Updated SAM and MCA.
- More detailed sectoral and sub-sectoral coverage including significant updates to the residential, road transport and AFOLU sector.
- A least-cost optimisation model in the electricity sector that draws demand figures from other sectors (endogenous electricity demand as opposed exogenous demand used in the 2014 MPA) to inform the build and generation plan. The electricity model does not include time of use data or grid stability considerations but has been assessed for adequacy.
- Additional stakeholder engagement to update mitigation measures available, uptake and mitigation potential.

- Investment costs for mitigation measures identified were also updated. For example, investment, fixed operational and variable operational costs of electricity generation technologies were updated to reflect the most recent cost data available.

The MCA was used in the MPA to explore multiple socio-economic and environmental impacts associated with mitigation actions, and how consideration of these in addition to cost and mitigation potential impact on the prioritisation of actions to be implemented. As part of the draft 2022 update to the MPA, the MCA was also reviewed to consider the human health impacts of local pollutants. In addition, the criteria and sub-criteria, approaches to scoring and weightings were updated based on inputs from stakeholders and the Technical Working Group.

In addition to the MPA, the DFFE also commissioned the GHG Pathways study in 2016. The GHG Pathways model provides an analysis of projected national GHG emission pathways for South Africa under different scenarios and builds on previous work completed by the MPA. The scenarios range from those under which no mitigation action is taken, to those in which mitigation action is taken in an economy with a structure largely similar to that of today, to those under which there is greater transformation of the economy. The different emission pathways are informed by factors including the country's existing and potential future (climate and non-climate) policies and measures; future economic developments; new science, evidence and information; and technological advances.

Following the GHG Pathways study, the internal PAMs study was commissioned in 2017 to consider the impact of Policies and Measures (PAMs) on national GHG emissions trajectory to 2050. This understanding is required to assess whether the current PAMs are sufficient to meet the overall mitigation ambition for the country, as contained in the NCCRP and South Africa's NDC commitments to contribute to the global mitigation effort in terms of the Paris Agreement, or whether government needs to implement additional PAMs. The model also provides an understanding of the socio-economic costs and benefits of a selection of planned PAMs by linking them to the SAM. Like the GHG Pathways study, the PAMs study builds on the previous work completed by the MPA.

The assumptions and input data (Section 3.8.1), emissions scenarios (Section 3.9) and total impact of mitigation (Section 0) as well as the cost of mitigation (Section 3.10), are presented in the sections that follow. The inputs and outputs presented are from the internal PAMs study, which represents the most recent available data and projections. It is important to note that this means the National GHG Inventory 2000 to 2020 is not utilised as historic data in the model results presented below. The study utilises the 2017 National GHG Inventory but for most sectors the base year is 2015 due to data availability at the time. In addition, the GDP and population does not include historic data up to the present (e.g., doesn't include the impact of COVID-19).

It should be noted that emissions pathways studies for South Africa historically indicated steep rising trends in emissions till 2050. More recent country-level studies (conducted after the PAMs study), indicate a flatter and potentially declining trend with a higher likelihood that South Africa could achieve its NDC mitigation targets. These trends are also observed in the National GHG Inventory. This difference is largely driven by the rapid changes and uptake of technology and technology prices over the past decade, as well as lower energy demand projections (due to a lower GDP growth and improved energy efficiency) (Merven et al., 2021). The lower energy demand and resultant decline in power sector emissions are largely attributed to electricity disruptions (known as loadshedding) (DFFE, 2022b). However, increased electricity cost (over the past decade, electricity prices in South Africa have increased by over 300%), slow economic growth and voluntary declines in electricity usage also contributed to lower emissions.

3.8.1 Overarching Assumptions

This section presents the assumptions underpinning the development of the three emissions scenarios, described below:

- WOM projection: assumes no climate actions have taken place since 2000.

- WEM projection: incorporates the impacts of climate change mitigation policies and measures implemented to 2020.
- WAM projection: assumes that existing, pipeline and potential future climate change mitigation policies and measures are implemented.

3.8.2 Cross-cutting Assumptions and Input Data

Key drivers of emissions include population projections, GDP growth and sectoral growth rates. The population projections are based on historic population data, provided by Statistics South Africa, with the projected population expected to reach 67 million people by 2050 (moderate projection), based on the CSIR population forecasts used in the 2016 IRP (CSIR, 2016). Two additional population projections are included in the PAMs study and are utilised in the sensitivity analysis. These projections see population reaching 65 and 76 million people by 2050, based on the Energy Research Centre's (ERC) [6] adjusted United Nations projections and the World Bank population estimates and projections (The World Bank, no date).

The PAMs study has three distinct GDP growth rate trajectories: low, moderate and high (shown in Figure 3-16). The projections assume that the structure of the economy remains largely unchanged (beyond the slight changes of differences in growth rates in certain sub-sectors). The low growth rate assumes GDP growth reaches a maximum of 2.4% in 2024 before declining to 1.8% from 2037 to 2050.The moderate growth scenario (used as the default growth in the PAMs study) reaches a high of 3.7% in 2026. This declines to 2.5% from 2045 to 2050. The high growth scenario projects growth reaches a high of 4.5% in 2022 declining to 3% by 2046 to 2050. In comparison the 2014 MPA (shown in Table 3-5), the GDP growth projections are much less optimistic. This has a significant impact on baseline emissions as GDP is a key driver of emissions.

Table 3-5: GDP growth rate per annum - MPA 2014

	2015 – 2022	2023 – 2032	2033 – 2042	2043 - 2052
2014 MPA – low	3.0%	3.3%	3.7%	3.9%
2014 MPA – moderate	3.6%	3.9%	4.3%	4.5%
2014 MPA – high	4.3%	4.5%	5.0%	5.2%

Source:(DEA, 2014)

Fuel and process emission factors are aligned with the IPCC 2006 Guidelines and include country-specific emission factors where possible (IPCC, 2006). The global warming potentials from the IPCC Second Assessment Report (SAR) are aligned with the national GHG Inventory (IPCC, 1995).

Although the 7th National GHG Inventory 2000 to 2017 is used as input data to the PAMs study, due to the granularity that is required in some sectors, especially the manufacturing sector, other activity data is also used, either provided by industry or through publicly available data.

[6] The ERC is based at the University of Cape Town (UCT)

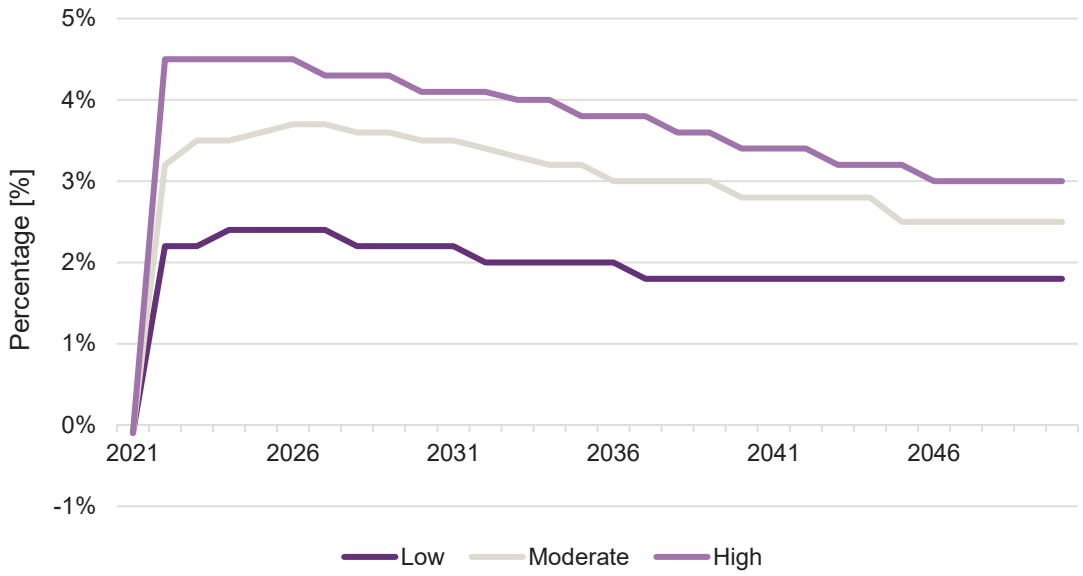

Figure 3-16 GDP growth rate 2021 to 2050

3.9 Projected Emissions Reduction Scenarios

The emissions from the PAMs study include projections for the WEM and WAM scenarios. The WEM and WAM projections trajectories are presented in Figure 3-17, along with the WOM scenario for comparison. In the WEM scenario, emissions are projected to be 512 $MtCO_2eq$ by 2030 and 519 $MtCO_2eq$ in 2050. The WAM projected emissions are 413 $MtCO_2eq$ in 2030 and 376 $MtCO_2eq$ by 2050. The WOM scenario (presented here for comparison) is extrapolated from 2000 and does not include any mitigation measures or interventions. Under this scenario emissions are projected to be 660 $MtCO_2eq$ by 2030 and 759 $MtCO_2eq$ in 2050. It is important to note that the results presented do not account for the impact of COVID-19, which had a substantial impact on the economy as a whole, alongside loadshedding, which has been increasingly prevalent.

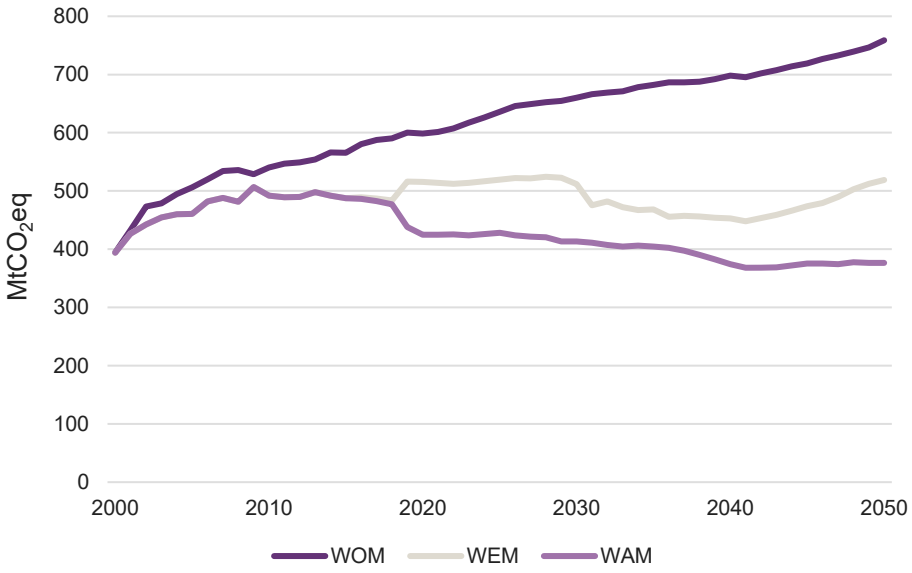

Figure 3-17: WOM, WEM and WAM emissions projections to 2050

The WEM and WAM projected emissions per sector are shown in Table 3-6 and Table 3-7. The projected emissions for both scenarios are dominated by the Energy sector, which contributes

between 67% and 84% of total emissions depending on the scenario and year. IPPU ranges from 8% to 18%, with AFOLU ranging from 5% to 9% and Waste from 3% to 7%. The WAM scenario shows a net emissions reduction in 2050 compared to 2010, driven by significant reductions in energy emissions, with other sectors all increasing over the time period.

Table 3-6: National GHG emissions under the WEM scenario by IPCC sector ($ktCO_2eq$)

	2010	2020	2030	2040	2050
Energy	411,810	426,573	409,215	330,954	379,210
IPPU	38,503	44,520	52,526	64,398	73,045
AFOLU	24,045	23,519	25,899	29,405	35,019
Waste	17,785	21,061	24,401	28,024	31,744
Total	**492,143**	**515,674**	**512,041**	**452,781**	**519,017**

Table 3-7: National GHG emissions under the WAM scenario by IPCC sector ($ktCO_2eq$)

	2010	2020	2030	2040	2050
Energy	411,810	340,039	324,327	268,334	250,796
IPPU	38,503	43,229	48,607	58,660	66,015
AFOLU	24,045	22,510	19,731	23,852	32,838
Waste	17,785	19,116	20,768	23,340	26,707
Total	**492,143**	**424,894**	**413,432**	**374,186**	**376,356**

3.9.1 Emissions Quantified per Gas

In the most recent 2020 national GHG Inventory, the GHGs reported on include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs). Indirect GHG (carbon monoxide, nitrous oxides and non-methane volatile organic compounds) are included for biomass burning only. Sulphur hexafluoride (SF_6) emissions are not included due to a lack of data.

South Africa's net GHG emissions in 2020 were predominately CO_2 (82.3%), followed by CH_4 (13.4%) and N_2O (3.2%), with HFC and PFC (F-gas) emissions contributing 1.1%. The Energy sector is by far the largest contributor to CO_2 emissions accounting for 94.7%, excluding FOLU.

In terms of CH_4, the AFOLU (51.1%) and Waste (38.2%) sector are the key emitters. In the AFOLU sector, the majority of emissions arise from enteric fermentation. The AFOLU sector (excluding FOLU) is also responsible for the majority of N_2O emissions (69,8%), mainly from direct N_2O emissions from managed soils along with manure management. The Energy sector accounted for 17.9% of N_2O emissions. The IPPU sector is responsible for 100% of F-gas emissions, originating from produce use as substitutes for ozone depleting substances.

Carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane volatile organic compounds (NMVOCs) were estimated from biomass burning only.

3.9.2 Energy

The Energy sector has the greatest potential to reduce emissions. It is projected that mitigation of 5,763 $MtCO_2eq$ over the entire time period is possible in this sector, with the Electricity and Heat production sub-sectors having the greatest emissions reduction potential. Solar PV and wind electricity account for 69% of the total emissions reduction throughout the time-period for this sector.

The mitigation measures with the top mitigation potential in the Energy sector are solar PV, wind and Combined-Cycle Gas Turbine (CCGT), all within the electricity sector.

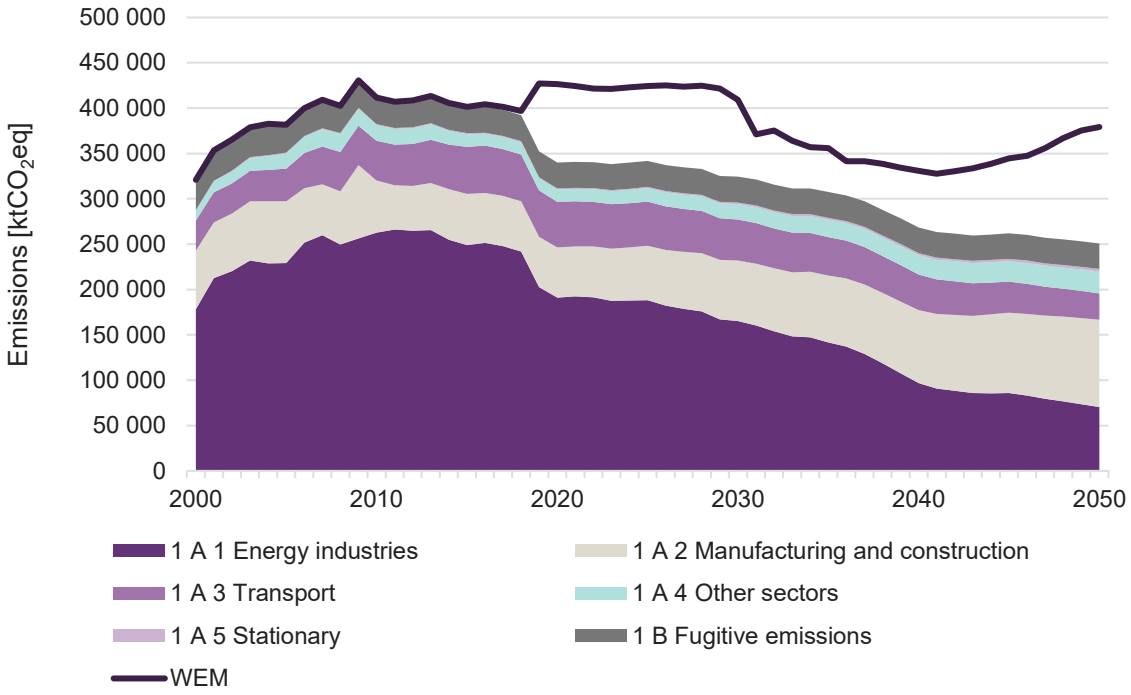

Figure 3-18: Energy sector WAM projections per sub-sector, in comparison to WEM - Energy

3.9.3 Industrial Processes and Product Use

The IPPU sector includes non-energy related emissions originating from industrial processes. The sector has a projected mitigation potential of 141 $MtCO_2eq$, with the Metals sub-sector accounting for 92% of the sectors' abatement potential.

The mitigation measures with the top mitigation potential in the IPPU sector are Electric Arc Furnace (EAF) and secondary production route, state-of-the-art power plant and DRI – Midrex, all within the iron and steel sector. These three mitigation measures account for 76% of the sector's abatement potential. EAF and secondary product route reduces process emissions by using scrap metal rather than carbon-intensive production technologies that use iron ore (DEA, 2014). State-of-the-art power plants can play a key role in mitigation in integrated steel works by using excess process gases and reducing flaring to provide both steam and power to key processes (DEA, 2014). Lastly MIDREX can reduce process emissions by producing iron using gas-based direct reduction in a shift furnace (DEA, 2014).

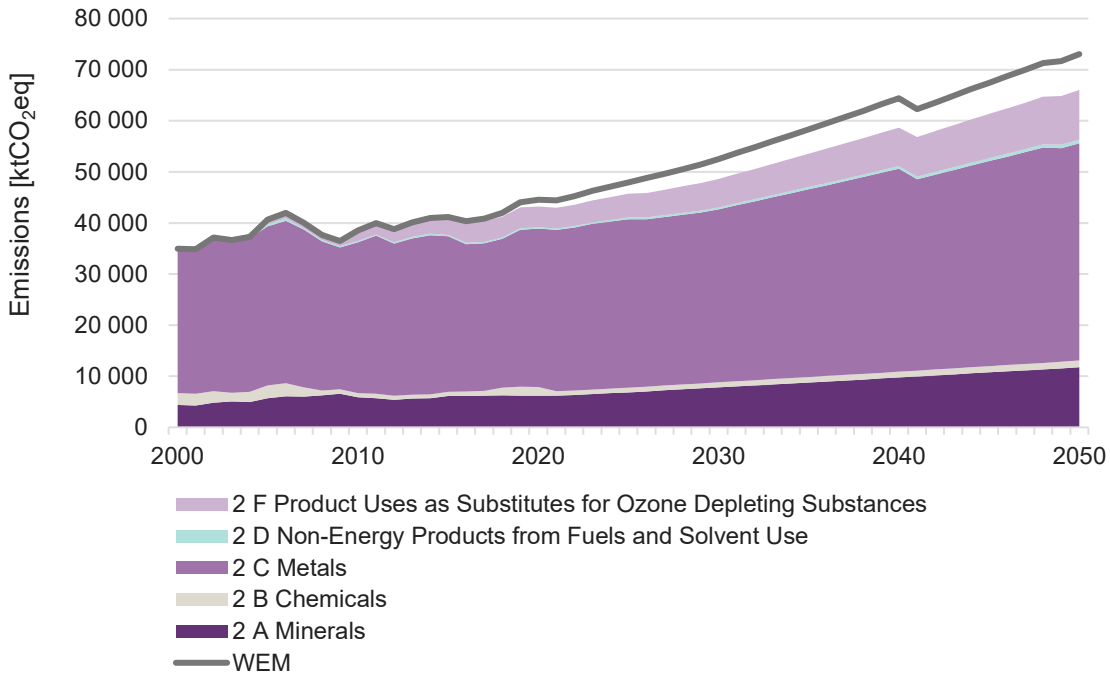

Figure 3-19: IPPU sector WAM projections per sub-sector, in comparison to WEM

3.9.4 AFOLU

The total emissions abatement potential in the AFOLU sector is 151 $MtCO_2eq$ over the time period, with the land sector accounting for most of the sectors' abatement potential.

The mitigation measures with the top mitigation potential in the AFOLU sector are the restoration of sub-tropical thick, forests and woodlands (72 $MtCO_2eq$) and the restoration and management of grasslands (54 $MtCO_2eq$). Both these measures lead to an increase in carbon sequestration. In addition, the reduction in degradation of grasslands decreases the release of soil carbon to the atmosphere.

3.9.5 Waste

The total emissions abatement potential of the waste sector (for managed waste disposal sites) is 125 $MtCO_2eq$ over the time period. This is largely from paper recycling and landfill gas recovery and flaring, responsible for 86% of the emissions reductions in this sector.

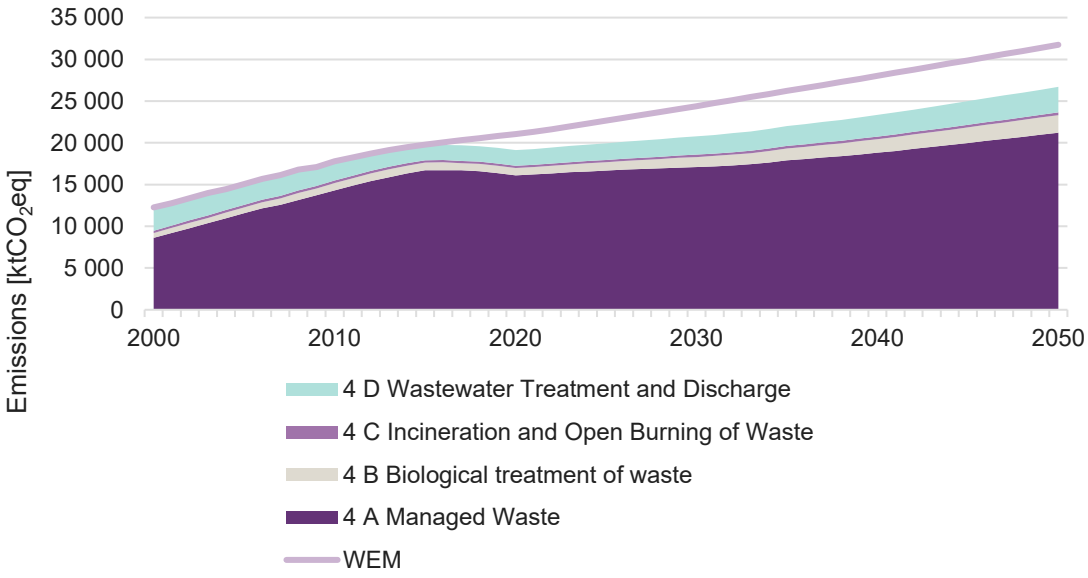

Figure 3-20: Waste sector WAM projections per sub-sector, in comparison to WEM

Total Impact of Mitigation

The PAMs study calculates the abatement potential of mitigation measures through to 2050 (from 2016). The difference between the WAM scenario (where all mitigation measures are implemented) and the WEM scenario (where only existing measures are implemented) is the abatement potential.

The accumulated national abatement potential of direct emissions for the study period (2016 to 2050) is estimated to be 2,872,448 $ktCO_2e$. The Energy sector is the biggest contributor (86%), followed by the AFOLU and IPPU sectors (approximately 5%) and lastly the Waste sector (4%).

Table 3-8 highlights the national top 10 mitigation technologies ranked by total abatement potential over from 2016 to 2050. The top 10 measures account for 87% of the total direct emissions abatement potential.

Table 3-8: Top 10 technologies' abatement potential

Rank	Sector	Technology type	Direct emissions abated [$ktCO_2e$]
1	Electricity sector	Solar PV	2,608,600
2	Electricity sector	Wind	1,372,771
3	Electricity sector	Combined cycle gas turbine	578,429
4	Road transport	Biofuels	229,070
5	Electricity sector	Import hydro	174,780
6	Iron and steel	Electric arc furnace and secondary production route	110,387
7	Non-specified industry	Energy efficient boiler and kilns	108,714
8	Road transport	Alternative fuels – electric vehicles	102,763
9	Forestry	Restoration of sub-tropical thicket, forests and woodlands	72,349
10	Managed waste disposal	Paper recycling	54,520
		TOTAL	**5,412,383**

3.10 Cost of Mitigation Measures

The cost implications of mitigation measures are quantified using Marginal Abatement Cost Curves (MACCs). The MACCs represent both the costs and the potential emissions abatement of each measure at a given point in time. The marginal abatement costs are presented as either positive or negative, where a negative cost is a cost savings.

Figure 3-21Figure 3-22 and Figure 3-22 highlights the top 20 MACCs for 2030 and 2050, ranked by lowest marginal abatement cost.

The following observations can be made from the MACCs:

- Eighteen[7] of the top 20 mitigation measures (ranked in terms of cost effectiveness of implementation) are in the transport sub-sector for the in 2030 and 2050.
- The top measures in terms of cost savings are petrol plug-in hybrid electric vehicles in 2030 and alternative fuels – CNG in 2050, both in the road transport sub-sector.
- Although solar PV and wind have the highest emissions abatement, these two technologies do not appear on the top 20 MACC. Although both options are cost negative there are more cost-effective options available, albeit with lower emissions savings.

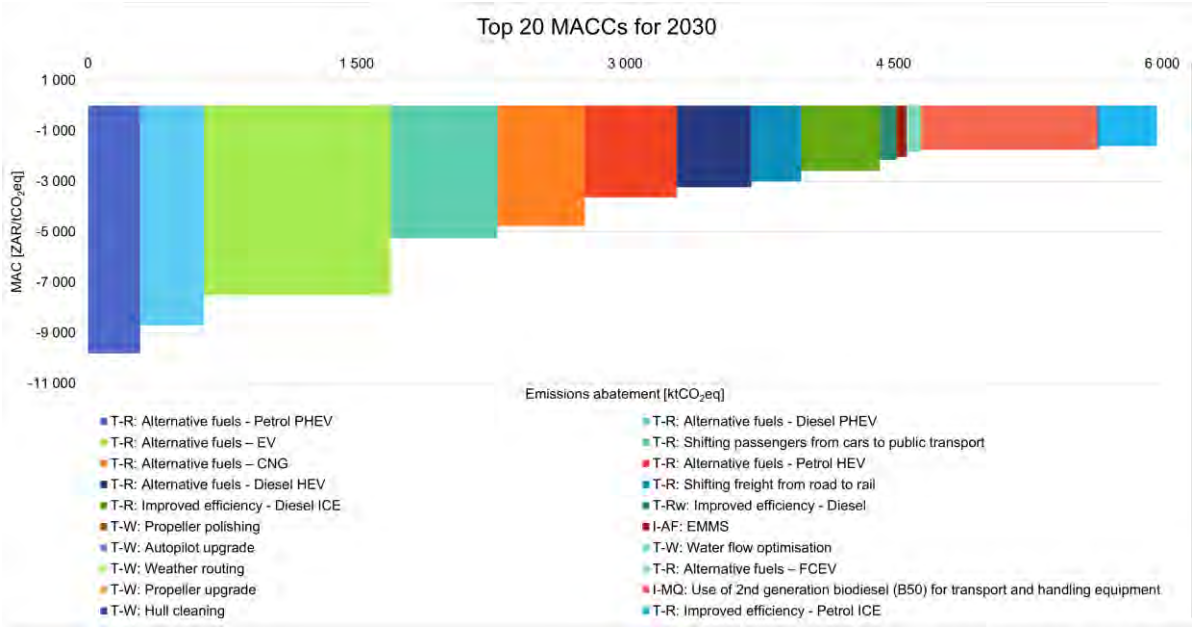

Figure 3-21: Top 20 mitigation measures in 2030, ranked by marginal abatement costs

[7] Sixteen in 2050

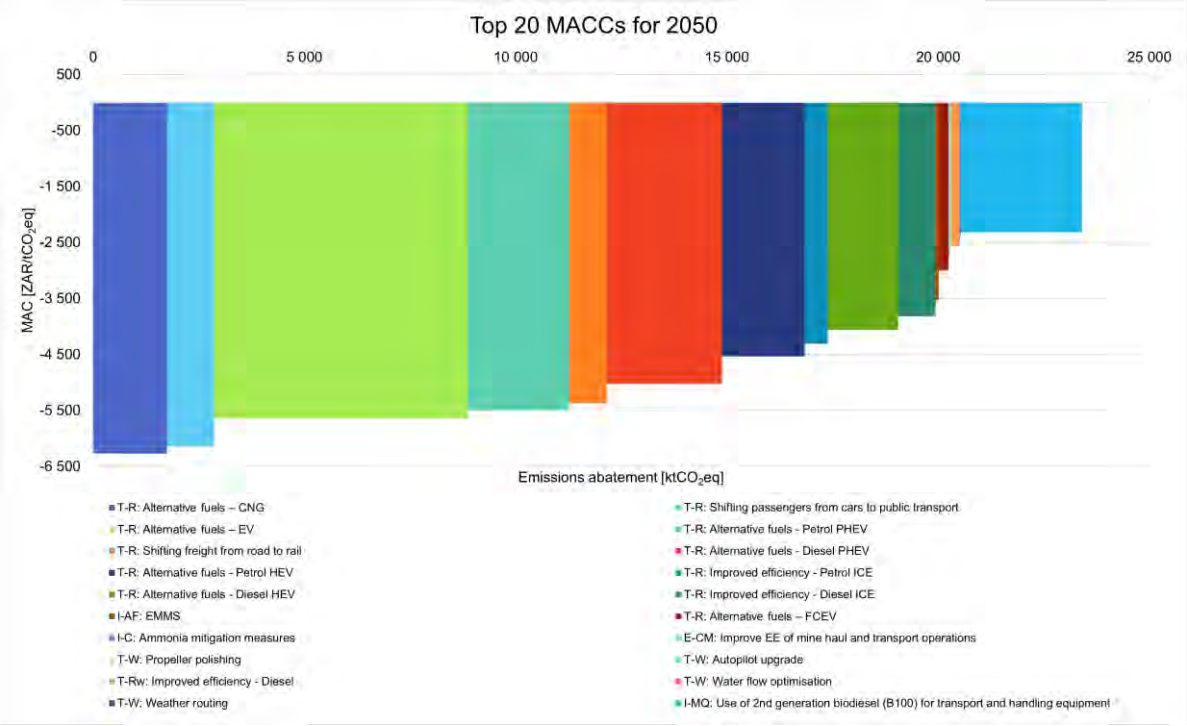

Figure 3-22: Top 20 mitigation measures in 2050, ranked by marginal abatement costs

3.10.1 Energy Sector

The Energy sector, particularly the electricity sector, has the greatest potential for mitigation. However, the least cost measures for this sector come from the transport sector (Figure 3-23). These includes, but are not limited to, plug-in hybrid road transport vehicles, electric vehicles and a modal shift from road to rail transport. It is important to note that the PAMs study does not include the cost of the infrastructure required to enable a fuel switch on a national level.

Figure 3-23 shows the MACC in 2030 for the electricity sector. Although solar PV and wind are not the most cost-effective measures in the Energy sector, they have a negative cost and the most significant abatement potential.

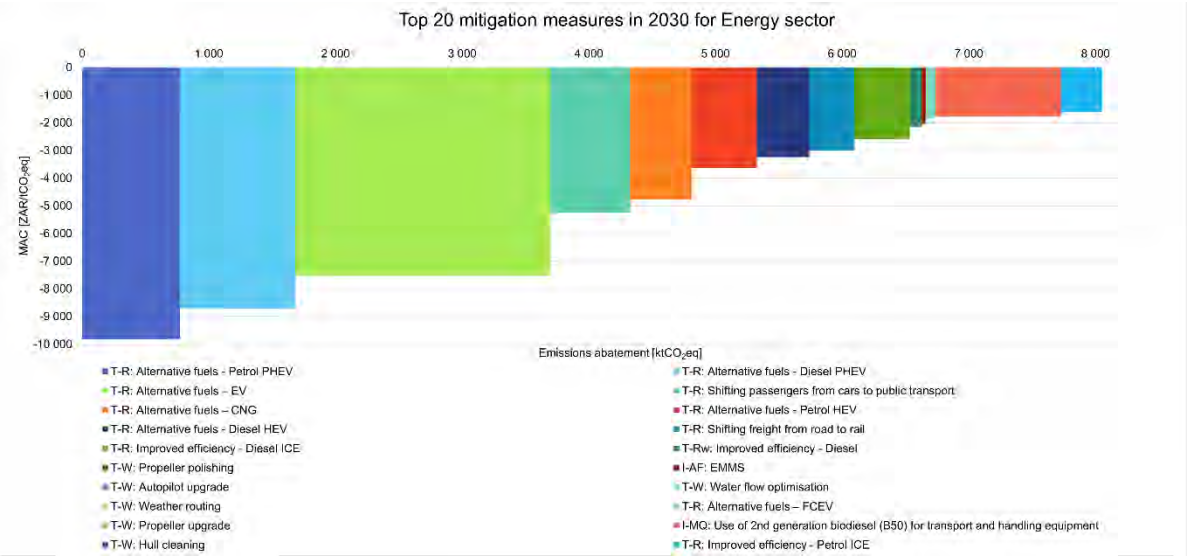

Figure 3-23: Top 20 mitigation measures in 2030 in the Energy sector, ranked by marginal abatement costs

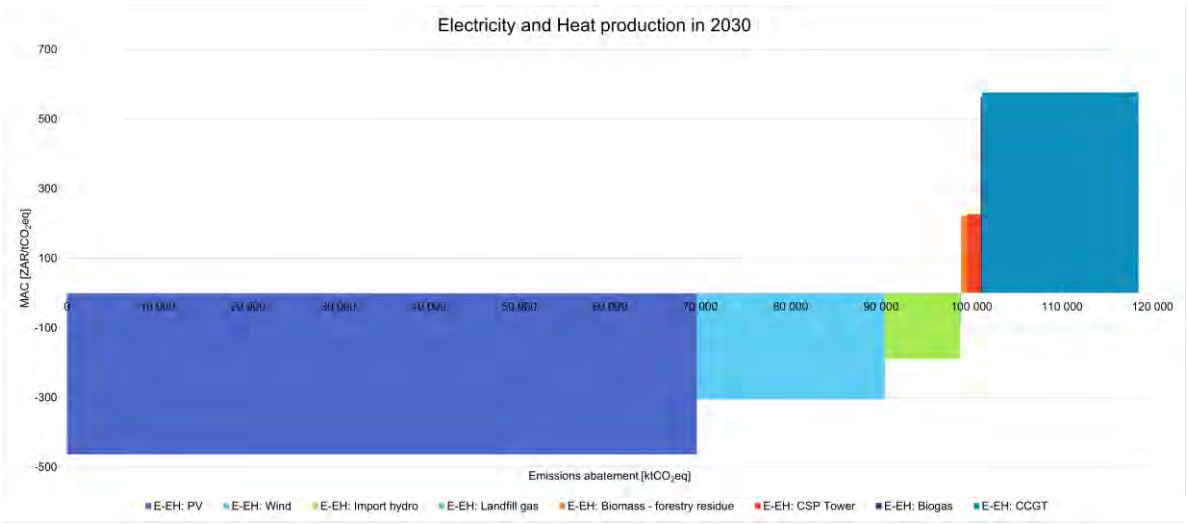

Figure 3-24: Electricity and Heat production Marginal Abatement Cost Curve in 2030

3.10.2 IPPU

The IPPU sector, which only considers process emissions from industry, considers 11 mitigation measures across the minerals, metals and chemicals sub-sectors. Of the 11 measures considered, two are cost negative:

- Use of alternative fuels in the lime industry; and
- Reduction of clinker content of cement products.

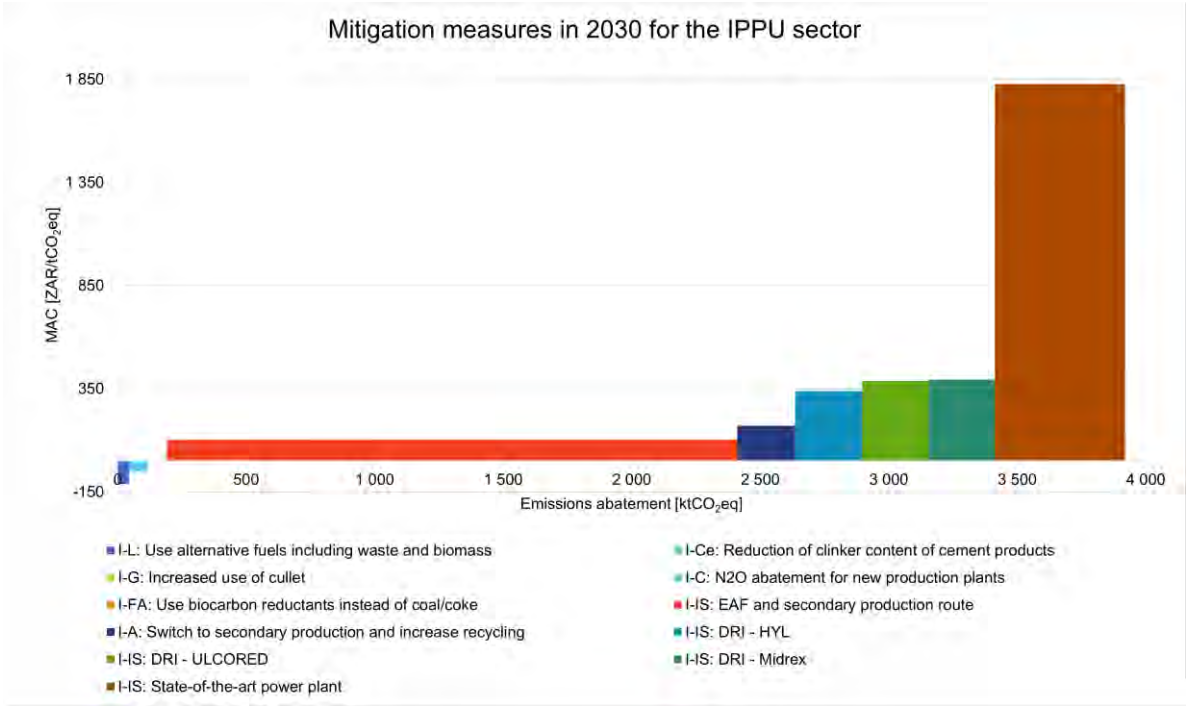

Figure 3-25: Mitigation measures in 2030 in the IPPU sector, ranked by marginal abatement costs

3.10.3 Waste

In the Waste sector, of the measures considered, only landfill gas (LFG) recovery and generation is cost negative (Figure 3-26).

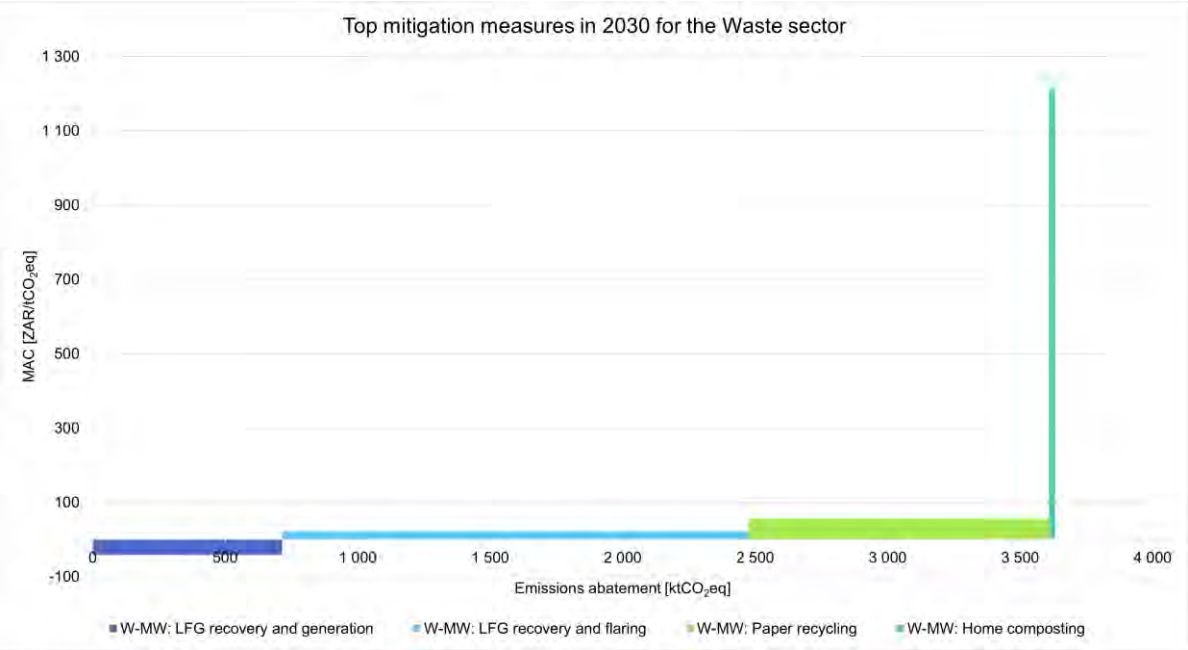

Figure 3-26: Top mitigation measures in 2030 in the Waste sector, ranked by marginal abatement costs

3.10.4 AFOLU

In the AFOLU sector, none of the mitigation measures considered are cost negative.

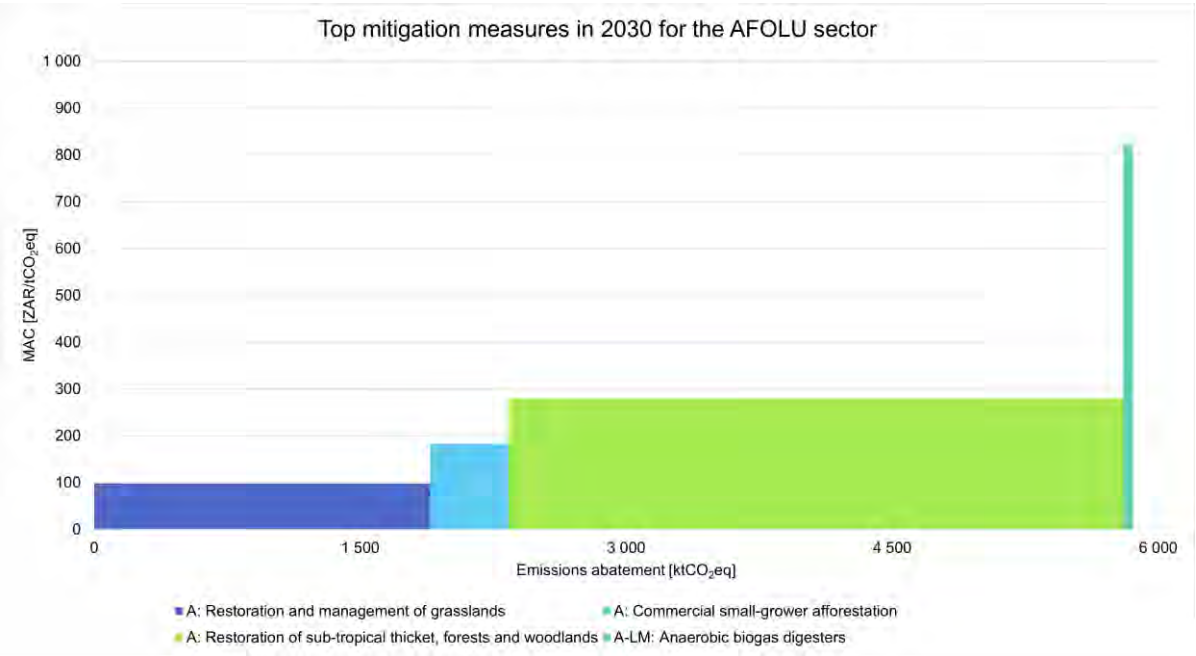

Figure 3-27: Top mitigation measures in 2030 in the AFOLU sector, ranked by marginal abatement costs

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4 Other Information Considered Relevant to the Achievement of the Objective of the Convention

4.1 Integrating Climate Change Considerations into Social, Economic and Environmental Policies and Actions

Integrating climate change considerations into social, economic and environmental policies and actions is a critical process for ensuring that climate change policies and national priorities are implemented concurrently, taking into account risks and opportunities while pursuing measures that are in tandem with the long-term development objectives of a country (OECD, 2009). Prioritising the pressing need to address climate change and its far-reaching impacts, South Africa has made significant progress in integrating climate change into its social, environmental and economic policies. The country has adopted a proactive, comprehensive approach by establishing robust policies, measures, legal frameworks and coordination mechanisms. Key economy-wide initiatives since 2017/18 have been outlined in detail in Chapter 1 of this report and include the National Environmental Management Action regulations on Pollution Prevention Plan (2017) and Greenhouse Gas Emissions reporting (2017), the Carbon Tax Act (2019), National Climate Change Adaptation Strategy (2020) and the Climate Change Bill (2022).

These efforts, together with international commitments under the Paris Agreement, local-level actions in cities and provincial climate change strategies, highlight South Africa's dedication to incorporating climate change considerations into all relevant policies and actions across the economy and building a climate-resilient and low-carbon future.

Additionally, Government has established a Climate Change Working Group to ensure that climate change objectives are integrated into all relevant policy areas (Averchenkova *et al*., 2019).

The sections below provide information on the integration from sectoral to national, provincial and regional strategies, policies, plans and priorities.

4.1.1 Integrating Climate Change Considerations into National Sectorial Strategies, Policies and Plans.

South Africa has advanced in integrating climate change measures into sector-specific policies, actions and strategies in sectors such as water, energy, transport and health (see Table 4-1).

Table 4-1: Sector specific climate change publications

Sector	Policy	Key Climate Change Considerations
Biodiversity and Ecosystem Services	National Biodiversity Strategy and Action Plan (2015-2025)	Ecosystem-based adaptation, conservation of critical ecosystems, restoration of degraded ecosystems and invasive species management.
Coastal Management	National Coastal Management Programme (2014)	Integrated coastal zone management, coastal setback lines, protection of coastal ecosystems, risk assessment and infrastructure adaptation.
Disaster Management	National Disaster Management Framework (2005)	Early warning systems, disaster risk assessments, capacity building, climate risk reduction and community-based disaster risk management.
Energy	Integrated Resource Plan (2019)	Transition to renewable energy sources, energy efficiency measures, decentralised energy systems and climate-resilient energy infrastructure.

Sector	Policy	Key Climate Change Considerations
Health	Climate Change and Health Adaptation Plan (2014)	Surveillance and monitoring of climate-sensitive diseases, heatwave action plans, capacity building for health professionals and emergency preparedness.
Transport	Green Transport Strategy (2018)	Promotion of public transport, non-motorised transport, electric vehicles, infrastructure adaptation to climate risks and resilience of transport corridors.
Water Resources	National Water Resource Strategy III (2023)	To ensure reliable current and future water supply inclusive of the effects of climate change.

By mainstreaming climate change considerations into each sector, government demonstrates its commitment to a holistic and coordinated response, effectively bolstering adaptation and mitigation efforts. While South Africa has made considerable strides, challenges persist in terms of capacity, resources and the need for ongoing investment in adaptation and mitigation measures.

4.1.2 Integrating Climate Change Adaptation Considerations into National Development Priorities and Policies.

4.1.2.1 The National Climate Change Adaptation Strategy

The National Climate Change Adaptation Strategy (NCCAS) 2020 outlines strategic goals and actions that will direct resource allocation and adaptation efforts across various sectors. It emphasises the integration of economic, social and environmental policies to create a robust and comprehensive response to climate change (DEFF, 2020). Among other things, this entails creating policies and programmes to assist adaptation measures in the fields of agriculture, aquaculture, sustainable energy usage, water management and management of natural resources. The strategy also recognises the need to build capacity in both the private and public sectors to support the implementation of adaptation measures. Additionally, the strategy promotes public awareness and education on the importance of adaptation measures and supports vulnerable communities in adapting to climate change.

Additionally, the NCCAS underlines the value of collaborating with local governments to help communities become more resilient to the effects of climate change and better equipped to adapt to it (DEFF, 2020). The strategy is advocating for the use of risk management measures to shield vulnerable areas from the effects of climate change and promotes the construction of infrastructure that is climate resilient.

Most importantly this strategy aligns with many of the United Nations' Sustainable Development Goals (SDGs), particularly those focused on climate action, poverty reduction and environmental sustainability.

The following table provides four NCCAS objectives and the category they represent, being either social, economic or environmental.

Table 4-2: Categories of NCCAS objectives

Objective	Social	Economic	Environmental
1. Build climate resilience and adaptive capacity to respond to climate change risk and vulnerability.			X
2. Promote the integration of climate change adaptation response into	X		

Objective	Social	Economic	Environmental
development objectives, policy, planning and implementation.			
3. Improve understanding of climate change impacts and capacity to respond to these impacts.	X		
4. Ensure resources and systems are in place to enable implementation of climate change responses.		X	

The following priority adaptation-related sectors are listed in the National Climate Change Response Policy (NCCRP): water, agriculture and commercial forestry, health, biodiversity and ecosystems, human settlements (urban, rural and coastal) and disaster risk reduction and management (DEA, 2011). The NCCAS additionally includes infrastructure, energy, mining, oceans and coasts as priority sectors, however, the strategy does not detail how adaptation will be implemented in the additional sectors that will be affected by climate change (DEFF, 2020).

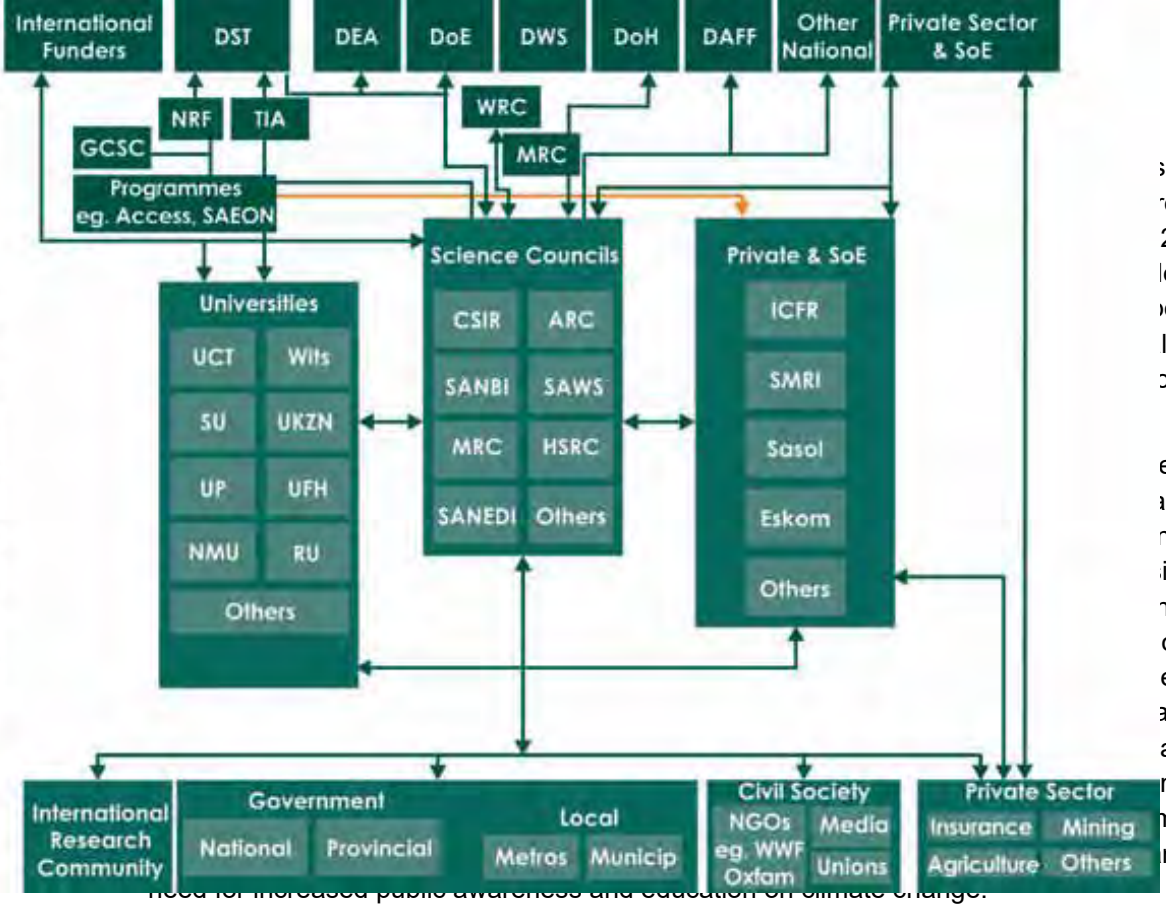
4.1.2.2 Development of the NCCAS

The NCCAS was meticulously developed as a coordinated response to the mounting challenges posed by climate change on the country's socio-economic and environmental sectors (DEFF, 2020). Anchored on several key policies and legislative frameworks, the NCCAS draws its foundation from Section 24 of the South African Constitution (1996), which emphasises the right to a healthy environment; the National Environmental Management Act (1998), which serves as the country's primary environmental law; the National Development Plan 2030 (2011), which envisions a climate-resilient future; and the National Climate Change Response Policy (NCCRP) (2011) which provides a blueprint for addressing climate change and integrating it into policy and planning processes. Other documents which influenced the NCCAS are the National Strategy for Sustainable Development (NSSD) (2011) of South Africa, South Africa's Nationally Determined Contributions (NDCs) (2015) and various sector adaptation plans, provincial adaptation plans and municipal adaptation plans.

The South African government, civil society, the business sector and other key stakeholders participated in a comprehensive multi-level consultation process that resulted in the development of the country's NCCAS (DEFF, 2020). Stakeholder workshops were held in the beginning of the process to discuss the condition of climate change adaptation in South Africa and to develop the first concepts for the plan. The approach was then further developed and consulted upon in further depth at a number of subsequent regional meetings. After being submitted for approval to the South African Parliament, the plan was formally published in 2017. The policy takes a multi-sectoral, integrated approach to responding to climate change, considering the relationships between various industries and fields of endeavour (DEFF, 2020). Additionally, it advocates for greater support for research and innovation as well as increased public involvement and engagement in decision-making processes. Lastly, other methodologies, such as risk evaluations, cost-benefit analyses, decision-making tools and information synthesis were also used to develop the plan.

4.1.2.3 The State of Preparedness for NCCAS Implementation

Taking into consideration the pressing need to address climate change and its impacts, South Africa has proactively developed a range of policies and legal frameworks to create an enabling environment for the implementation of adaptation measures (CSIR, 2019). Among these, the Climate Change Bill (2022) stands as a pivotal piece of legislation that reinforces the country’s commitment to addressing climate change. The Climate Change Bill establishes a comprehensive legal foundation for the coordinated response to climate change, addressing both adaptation and mitigation efforts in a holistic manner. By providing a clear mandate, governance structures and accountability mechanisms, the Bill, once enacted, will enhance the preparedness of the country to implement the NCCAS effectively.



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4.2 Development and Transfer of Environmentally Sound Technologies (ESTs)

This section reports on South Africa's status on climate change science and technology, technology needs for climate change mitigation and adaptation, as well as the technology barriers South Africa faces for both adaptation and mitigation.

4.2.1 State of Climate Change Science and Technology in SA

The State of Climate Change Science and Technology (S&T) in South Africa Report was published by the Academy of Science of South Africa on behalf of the Departments of Science and Technology (DST) and the Department of Environment, Forestry and Fisheries (DEFF) in 2019 (ASSAf, 2019). This report covers the period 2016 – 2017 and reports on Climate Change Science and Technology activities/initiatives which took place in South Africa during that time period. This section presents a summary of the main findings of the report.

Firstly, a landscape of climate-related science and technology (S&T) that is comparatively advanced, complicated and well-established, is shown in Figure 4-1 below. This serves to demonstrate how climate change has either a direct or indirect impact, on practically all South African institutions, whether they be public, private or civil sectors.

Figure 4-1: Climate Change Science and Technology Landscape in South Africa (ASSAf, 2019)

Secondly, it was determined that numerous initiatives and funding opportunities were used. According to the first biennial study (period 2015-2016) the country invested around R400 million in S&T related to climate change (ASSAf, 2017). The annual value is closer to R900 million recorded in the second biennial report (ASSAf, 2019). The private sector's funding (including SoEs) and support from international financial instruments account for a major portion of the difference, which is mostly used for technology development in the field of climate mitigation. With more investment, the biennial report also found high citation rates for studies on climate change. A total of 104 doctoral degrees and 120 master's degrees in climate change research were granted in the academic year of 2016–2017 (ASSAf, 2019). The number of South Africans who have received postgraduate degrees relevant to

climate change has increased, although it is still both racially and gender unbalanced. Additionally, South African scientists were involved in international research activities. The researchers were chosen to take part in global climate organisations like the Intergovernmental Panel on Climate Change (IPCC), where they collaborated with 13 other experts, as well as other groups like the Global Climate Research Programme and the International Science Council. Even though it was noted that South African scholars were active in international networks, there may still be apparent gaps in their relationships with Africa and the BRICS nations.

One of the biggest challenges in the quantification of the exact funding figure for research into climate change in South Africa is due to missing data (ASSAf, 2019). Using material from commissioned studies, annual reports and personal communications, the second biennial report on climate change S&T in South Africa (2019) fills in the gaps from the first report by outlining investment in climate change research and development. According to the report, university and science council grants from national government organisations were a significant source of funding for scientific research and technical advancements. Significant investment in climate change S&T also comes from the business sector. Through bilateral partnerships with nations like Norway, Poland, India and Tunisia, as well as through external funding sources like the Clean Technology Fund, South Africa has made investments in S&T related to climate change. In South Africa, nearly R2 billion was invested in climate change science and technology between 2015 and 2017.

According to the State of Climate Change Science and Technology in South Africa Report, only 16 out of 37 international climate finance instruments available for investments in S&T for reducing and adapting to climate change have been used by South Africa. However, in recent years, expenditure in research and development linked to climate change has increased. The majority of the funds from international assistance that our country received went towards mitigating climate change. Nonetheless, there is a chance that more funding will come from other global financial instruments. Table 4-3 below provides the sources and levels of investment (ZAR million) in Climate Change Science and Technology in South Africa for the years 2015 to 2017.

Table 4-3: Sources and levels of investment (ZAR million) in Climate Change Science and Technology in South Africa, 2015 – 2017 (ASSAf, 2019)

Source of Funding	Implementing/Host Agency	2015	2016	2017
Grand Total (ZAR million)		**527.58**	**1 063.84**	**1 037.32**
1. National		439 (83%)	754.36 (71%)	702.87 (68%)
1.1 Public Sector (% of total)		**329.75** (63%)	**659.35** (62%)	**606.42** (58%)
Department of Science and Technology		256.76 (49%)	474.81 (45%)	459.20 (44%)
	ACCESS	16.20	8.42	9.80
	SAEON	14.26	6.91	7.10
	FBIP	10.93	5.30	5.44
	GCSSRD	7.00	3.39	3.48
	RVSCs	6.00	2.91	2.99
	AEON	6.93	3.36	3.45
	SOCCO	9.00	4.36	4.48

Source of Funding	Implementing/Host Agency	2015	2016	2017
	SARVA	3.63	1.76	1.81
	SAASTD	112.69	66.66	69.19
	NRF	39.62	24.68	14.88
	Bilaterals ARC		0.13	0.19
	Bilaterals Other (universities, consultants, etc.)		12.87	3.74
	Socioeconomic Innovations Programme		11.68	10.95
	GCGC Waste Research South African Research Chairs Initiative (CSIR)		241.12	223.80
	CSIR	28.00	29.65	31.11
	SANBI	2.50	7.79	10.98
	SAMRC		2.00	1.70
	TIA		66.50	69.00
Department of Energy			(0.5%)	(0.2%)
	SANEDI		5.25	2.25
Department of Environmental Affairs		(9%)	(2%)	(4%)
	SAWS	44.99	19.03	38.85
Department of Agriculture, Forestry & Fisheries				
	ARC		5.04	1.62
Department of Trade & Industry				
	IDC		7.65	6.50
	WRC	28.00	3.60	2.30
	CSIR		1.55	0.42
	ARC		0.88	0.24
	Other (universities, consultants, etc.)		1.17	1.64
Other Government (DEA, DE&M, DST, DTI)			**144.00 (14%)**	**95.70 (9%)**
	SANEDI		90.37	34.65
	SAWS		0.34	0.44
	Co-finance several programmes with foreign donors		53.29	60.61
1.2. Private Sector including SOEs		**110.00** (21%)	**94.98** (9%)	**96.45** (9%)
ESKOM		**50.00**	**50.00**	**50.00**

Source of Funding	Implementing/Host Agency	2015	2016	2017
SASOL		**60.00**	**30.00**	**30.00**
DBSA	Capital Solutions (Green Fund)		**7.50**	**7.50**
VC (Venture Capital)	**Several private & public enterprises**		**4.42**	**5.89**
Anglo American			**3.06**	**3.06**
2. Foreign		**87.83** (17%)	**309.88** (29%)	**334.46** (32%)
2.1. Global Instruments		**0.00**	**267.84** (25%)	**291.87** (28%)
Clean Technology Fund			262.22	285.78
	Eskom		151.67	163.33
	Several Public & Private Enterprises		110.55	122.45
Green Climate Fund	Capital Solutions (Green Fund)		5.36	5.84
Adaptation Fund	SANBI		0.26	0.25
2.2. Other Foreign		0.00	**42.04** (4%)	**42.59** (4%)
UNIDO				
	TIA		0.60	0.73
Bilateral from several countries	Several Public & Private Enterprises		**20.24**	**20.24**
Belmont Forum (SIDA, Sweden)	Several Public & Private Enterprises		0.25	0.25
Other			20.95	21.37
	SAWS		1.16	1.58
	SANEDI		19.79	19.79

From 2003 to 2017, the private sector received funding from international donor funding organisations totalling over $520 million for clean energy technology projects (ASSAf, 2019). Financing has primarily prioritised mitigation over adaptation. Nonetheless, South Africa offers a range of green funding options, including the Green Fund and incentives for private businesses. The country is also looking into novel financing options for initiatives aimed at improving water and energy efficiency. Investment managers have created financial instruments to draw institutional and retail funding for renewable energy (RE) projects.

One of the biggest barriers in the private sector's investment in climate change activities is that compared to climate adaptation, private funding has primarily gone towards mitigation because it is easier to quantify a return on investment (ASSAF, 2019).

4.2.2 Technology Needs for Mitigation

In terms of mitigation, technology needs mainly exist in the industrial sector, particularly on technologies that can assist in improving energy efficiency. Table 4-4 below presents the prioritised technology needs for mitigation of climate change in South Africa. It shows that waste sector technologies, particularly related to the switching from using raw materials to recycled materials, is a key priority in the country.

Table 4-4: Prioritised Technologies for Mitigation (CSIR, 2019).

Mitigation sector	Prioritised technology	Justification / motivation
Industry	Aluminium – Energy monitoring and management system	• Sector plays an important role in national economic development. • Largest contributor to GHG emissions in the industrial sector. • Improving energy efficiency could make production of aluminium more competitive.
	Utilise waste material (such as old tyres) as fuel in cement production	• Improves efficiency of cement production while reducing dependence of fossil fuels and GHGs. • Potential to supply waste energy through Combined Heat and Power combustion systems (CHP) and co-generation to neighbouring communities.
	Aluminium – Secondary production and recycling	• Allows for re-use of aluminium scrap. • Environmentally sound process that is more energy efficient than primary production.
Waste	Higher value and marketable byproducts from food waste	• Enterprise development and diversion of organic waste from landfill.
	Separation at source and waste recovery services by small businesses	• Increased community participation rates in recycling programs. • Sustainable job creation.
	Anaerobic digestion (large scale)	• High mitigation potential. Production of electricity. • Solid by-products can be turned into compost and fertilizer.

4.2.3 Technology Needs for Adaptation

Table 4-5 below presents prioritised technologies for climate change adaptation.

Table 4-5: Prioritised Technologies for The Adaptation Sector (CSIR, 2019).

Adaptation Sector	Prioritised technology	Justification / motivation
Agriculture, Biodiversity and Forestry	Urban Forestry	Promotes adaptation to heat stress by providing shading and evaporative cooling, rainwater interception and storage and infiltration for cities. Potential to act as carbon sinks.
	Conservation Tillage	Reduces runoff risk though enhanced soil-moisture retention and minimising soil impaction. High ecosystem benefits through carbon sequestration in organic matter accumulation in the soil from use of residues and cover crops.
	Wetland restoration and protection	High ecosystem benefits. Contributes to water sector priorities. Potential for improved livelihoods.

Adaptation Sector	Prioritised technology	Justification / motivation
	Biorefinery	Maximises value-added products obtained from biomass through more efficient, optimised processes. Cross-cutting in agriculture, forestry, fisheries, waste and industry sectors.
Fisheries	Rapid screening tools for imported wild caught, aquaculture products and bait	Supports rapid health assessment of wild and imported fish (and bait) in line with aquaculture requirements.
	Early warning systems for forecasting extreme events	Supports disaster risk management and adaptive responses to extreme weather events and has the potential to save lives.
	Early warning systems to detect changes in algal blooms	Risk reduction in terms of impact on aquatic ecosystems, human health and the economy.
Human Settlements	Disaster risk reduction: Sustainable urban drainage systems	• Improving the resilience of urban built-up environments to flooding. • Enterprise development for the production of sustainable urban drainage system technologies. • Job creation. • Reduce the contamination of storm water from pollutants.
	Low elevation engineering	• Job creation in the building and construction sector. • Protection of coastal zones from flooding.
	Disaster risk reduction: Fire-retardant building materials for low cost and informal housing	• Enterprise development for the formulation of fire-retardant materials and the design of fire-resistant houses. • Increase the adaptive capacity of human settlements to natural disasters.
Water	Low pour-flush toilets	• Suitable for areas with low water availability. • Water saving (uses 1–2 L per flush).
	Rainwater harvesting	• Increase diversity and optimisation of mix of water sources. • Improve the reliability of water supply in rural areas and municipalities where services are unreliable.
	Desalination technologies for brackish water, ground water, mine water and seawater	• Increase ability to make use of more sources of water. • Potential to add jobs to the Blue Economy.

The table shows that urban forestry, conservation tillage, wetland restoration and protection and biorefinery scored the highest in addressing climate change and ecosystem benefits in the agriculture, biodiversity and forestry sector. Organic agriculture/ farming, multiple land use and managing and monitoring invasive alien species technologies were other potential technology options to consider in the sector.

For the human settlement sector, priority technologies relate to disaster risk reduction in terms of improved stormwater drainage, the use of fire-retardant building materials, as well as low elevation engineering that provide for coastal protection measures.

Low pour flush toilets, rainwater harvesting and desalination are currently being implemented across the country as the highest scoring prioritised technologies for the water sector. These technologies also have the potential to contribute to challenges around water pollution and water resource availability.

4.2.4 Barriers to Mitigation Technologies

In 2015, the Department of Science and Technology (DST) and the Department of Environmental Affairs (DEA), as it was then known, identified barriers to the first cluster of mitigation technologies in the following categories: policy and regulatory, access to information, technical, research and development (R&D), cost or financial and technology transfer barriers. Table 4-6, Table 4-7 and Table 4-8 provide an overview of barriers to adoption of mitigation technology in the energy, IPPU and waste sectors.

Table 4-6: Barriers to Energy-Related Mitigation Technologies Prioritised in The DEA and DST Mitigation Technology Plan (DEA and DST, 2015)

Mitigation Technology or Technological System	Description of Barriers
Carbon capture and storage (CCS)	• Lack of policy and regulatory clarity and certainty. • Insufficient knowledge of and information on, the effectiveness of the technology. • Limited domestic R&D conducted in South Africa. • Weak or limited human skills-base to support CCS development. • Underdeveloped market and private sector interest in CCS are not articulated.
Advanced biofuels	• Lack of policy and regulatory clarity and certainty. • Insufficient knowledge of and information on, the effectiveness of the technology. • Social resistance (mainly by environmental activists). • Socio-economic and environmental impacts research not well done. • The underdeveloped market for biofuels.
Smart grids	• Insufficient knowledge of and limited information on, technology (its availability and effectiveness). • Underdeveloped market and private sector investment is limited. • Poor or underdeveloped physical infrastructure for deploying the technology in rural areas.
Solar photovoltaics	• Underdeveloped human skills-base (limited number of skilled installers with technical skills). • Lack of proper standards for performance and quality management. • Relatively high installation costs for rural poor households. • Limited public information/awareness of economic and environmental benefits of the technology. • Financing of technology commercialisation is scarce or limited.
Solar water heaters	• Underdeveloped human skills-base (limited number of skilled installers with technical skills). • Lack of proper standards for performance and quality management. • Relatively high installation costs for rural poor households. • Limited public information/awareness of economic and environmental benefits of the technology.
Energy efficient lighting	• Lack of policy and regulatory clarity and certainty. • Inadequate infrastructure and accessibility of technology in rural areas. • Relatively high cost of technology for poor rural households.

Mitigation Technology or Technological System	Description of Barriers
Variable speed drives and energy efficient motors	• High-cost large-scale rollout. • Limited public information/awareness of economic and environmental benefits of the technology. • Lack of incentives for private investment in the development of the technology. • Underdeveloped/limited human skills-base (short supply of engineers and system designers).
Energy efficient appliances	• The relatively small market for energy efficient appliances such as refrigerators. • Limited public information/awareness of economic and environmental benefits of the technology. • High costs of acquiring the technology by rural poor households.
Energy storage technologies	• Poor knowledge of and limited information on technology (its availability and effectiveness). • Underdeveloped market and private sector investment is limited. • Poor coordination and/or linkages between R&D (e.g., CSIR) and industry (e.g., IDC).
Hybrid electric vehicles	• Limited knowledge and information (awareness) of the technology and its effectiveness and economic benefits as well as environmental benefits. • High upfront costs of purchasing hybrid electric vehicles. • Limited financing for domestic R&D on the technology. • Insufficient coordination between departments of transport, energy, science and technology and finance undermines efforts to develop a national policy and strategy. • Intellectual property protection (barrier to local manufacturing).
Wind (Onshore)	• Small domestic market and lack of incentives (including financing) for the private sector, particularly SMEs. • Underdeveloped manufacturing base for technology components. • Technological lock-in in coal-generated electricity by Eskom. • Lack of policy and regulatory clarity on nuclear power/energy. • Social resistance and politicisation.
Nuclear pressured water reactor (PWR)	• Lack of incentives to attract domestic private sector investment. • Limited human skills-base to conduct R&D and develop as well as deploy the technology. • High costs of technology.

Table 4-7: Barriers to IPPU-Related Mitigation Technologies (CSIR, 2019).

Mitigation Technology or Technological System	Description of Barriers
Improving energy efficiency in primary aluminium products	• Limitations of the technologies used in the electrolysis process. • New equipment or changes to processes may also need to be implemented, these would be industry-site specific and could be costly. • The demand to produce more metal from existing capacity shifts the focus to increasing the electric current in the electrolytic process, rather than reducing it.
Anode technology selection for primary aluminium smelting	• Research and further investigations into the best available technology (based on the existing equipment and design) is required. • International development and testing of these new technologies are occurring, with a limited market in South Africa.

Mitigation Technology or Technological System	Description of Barriers
Switch from coal to biomass / residual wood waste in the paper and pulp industry	• The investment costs of new equipment and retrofitting boilers inhibits private sector investment.
Basic Oxygen Furnace in the production of iron and steel	• The use and installation would be subject to limitations associated with the location of existing equipment and plant design. • The cost of the system might also prevent private sector investment.
Waste material as a fuel in cement production	• Scrapped tyres are spread out across the country, so the correct procedures for collection, classification and storage are required. • Public concern about the increase in air pollution emissions and the release of toxic gases, such as dioxins, might reduce interest in such an investment.
Combined heat and power (CHP) in the paper and pulp industry	• High initial capital costs of implementing a CHP system.
Energy Management and Monitoring System	• Limited finances and awareness of the options available might make industries hesitant to invest, especially if the production process is complex. • Unless there are incentives to invest in energy efficiency, capital investment is likely to prioritise areas of the production process that require it more urgently (i.e., investments that can directly improve productivity).
Improvement of process monitoring and control	• The capital costs and the return time on investment would need to be understood to convince industries of the return on investment.
Top Gas Recycling (with CCS)	• The stage of development of such technologies and its track record might make private sector wary of investment.

Table 4-8: Barriers to Waste-Related Mitigation Technologies - Waste Sector (CSIR, 2019)

Mitigation Technology or Technological System	Description of Barriers
Recycling - Higher value and marketable by-products from food waste	• Small scale operations are not practical. • Contamination of post-consumer food waste usually from packaging, household objects and non-recyclables make extraction costly. • Contamination risks of post-consumer food waste from household hazardous waste. • Lack of enforcement of separation at source of commercial food waste, especially from shopping centres and restaurants.
Recycling - Separation at source and waste recovery services by small businesses	• Enforcement of separation at source in the residential, commercial and industrial sectors is insufficient. • The informal sector, which is recognised, is left largely to operate in its current form. • Lengthy engagements with informal waste pickers to integrate them into co-operatives and small businesses have shown that the loss of revenue for pickers makes participation in the formalisation process unattractive to them. • Infrastructure and resources are lacking for the success of co-operatives, including transport, equipment, premises to work and electricity supply.

Mitigation Technology or Technological System	Description of Barriers
	• Operational challenges include theft of recyclates, finding markets to sell recyclates and networking. • Insufficient training of waste pickers to operate small businesses including technical, governance and business management skills. • Underdeveloped relationships between co-operatives and local government. • Lack of start-up and working capital.
Anaerobic digestion: large scale from both industrial and municipal waste	• Capital-intensive. • Source of GHG emissions. • Most organic waste ends up in landfills.
Anaerobic digestion of municipal and industrial wastewater sewage sludge with Combined Heat & Power (CHP)	• Low gas yields due to issues relating to the sludge management component of the plant can result in lower gas production than anticipated. • Human faecal waste which mixes with municipal effluent cannot be used as a feedstock since pathogen reduction by mesophilic anaerobic digestion is insufficient.
In-vessel composting	• Capital intensive. • Requires extensive training of personnel. • High maintenance and operational costs.

4.2.5 Barriers to Adaptation Technologies

The implementation of the technologies listed for climate change adaptation can be impeded or hindered by a range of policy, institutional, social and technical factors. There are policy and institutional issues pertaining to land and resource tenure in general. Ownership of land and land size influences technology choice and implementation. The development and implementation of some of the technologies may be impeded by lack of policy and regulatory clarity as well as social resistance. Scarcity of human resources and limited funding are impediments to R&D and barriers to implementation of technologies may include lack of information and high costs for small scale rural farmers. A comprehensive list of barriers for the adoption of climate change adaptation technologies is presented in Table 4-9 to Table 4-13 below.

Table 4-9: Barriers to AFOLU-Related Adaptation Technologies (CSIR, 2019)

Type of technology or technological system / field	Barriers to technology development and implementation
Urban forestry and vegetation	• High implementation cost depending on location. • Some municipal laws are an impediment, particularly land tenure restricting farming practices in municipalities.
Biorefinery	• High investment costs and operational expenses. • Need for development of skills to build and operate new technologies. • R&D funding constraints.
Organic agriculture	• Inadequate incentives for implementation of organic agricultural technologies due to low potential to capitalise further investments.

Type of technology or technological system / field	Barriers to technology development and implementation
	• Weak technical standards for inspection and certification of organic products from small-scale farmers in rural parts of the country.
Integrated pest management	• Limited technical skills among farmers, particularly in rural areas. • High costs of equipment and other materials for small-scale farmers in rural areas. • Low incentives, particularly for small-scale farmers, due to limited potential to capitalise new investments.
Monitoring and managing invasive species	• Limited R&D funding. • Poor institutional coordination between provinces and national government departments. • Underdeveloped public-private sector collaboration.

Table 4-10: Barriers to Fisheries-Related Adaptation Technologies (CSIR, 2019)

Type of technology or technological system / field	Barriers to technology development and implementation
Technologies for the rapid health assessment of wild and imported fish (and bait)	• Additional R&D are needed for application in the local context. • Protocols and training of customs/airport staff in aquatic health and hazards. • Training needed in local labs.
Early warning systems for forecasting extreme events	• R&D funding constraints. • User confidence in the degree of uncertainty.
Early warning systems for detecting changes in algal blooms	• R&D funding constraints. • Availability of good quality real-time data may be limited. • User confidence in the degree of uncertainty. • Methods for communication of information to users and ownership of management i.e., who will manage system?

Table 4-11: Barriers to Water-Related Adaptation Technologies (CSIR, 2019)

Type of technology or technological system / field	Barriers to technology development and implementation
Rainwater harvesting	• High cost to install across all income groups. • Lack of incentives for broader adoption.
Desalination	• High infrastructure investment. • High financial viability and operational efficiency to be a successful alternative water supply. • High maintenance costs. • Energy-intensive. • Requires skilled personnel.
Protecting and restoring ecological infrastructure	• Need for secure financial flows for restoration and ongoing maintenance of ecological infrastructure. • Need for improved institutional capacity for investment in ecological infrastructure.

Type of technology or technological system / field	Barriers to technology development and implementation
	• Competition for land.
Reducing system leakages	• Need for area-specific assessments and interventions – municipality needs vary depending on the root causes of water losses. • Lack of capital in most municipalities to buy the technology (models/software and training costs). • Lack of implementation of the policies and regulations which are already in place when it comes to leak detection.
Low pour-flush toilets	• Needs a reliable water supply – assessment of the reliability of water supply must be done prior to implementation. • Local authorities must clarify the responsibilities of operation and maintenance. • Need for plans by municipalities for disposal of leach pits. • Assessment of suitability needed in areas with high water table or sensitive ecosystems.

Table 4-12: Barriers to Settlements-Related Adaptation (CSIR, 2019)

Type of technology or technological system / field	Barriers to technology development and implementation
Disaster risk reduction - Improved stormwater drainage systems/upgrade	• High investment costs and low availability of expertise required to successfully implement upgrades. • Depending on the level of existing infrastructure in an area, implementation could be expensive, for example, in an area with little existing infrastructure that is compatible with new technology.
Low elevation engineering	• The cost of construction options such as new groynes or well-designed seawalls may limit the use. • A further barrier may be the availability and cost associated with the specialised equipment and contractors needed for processes such as dredging. • Some dune management options may have a requirement of an Environmental Impact Assessment before commencement, resulting in additional costs and lengthier timeframes. • Gaining buy-in from the public and municipal officials for the need of artificial dune creation or dune rehabilitation projects.
Disaster risk reduction - fire-retardant building materials for low cost and informal housing	• Typically undertaken as pilot projects – highlighting the need for innovation and markets for affordable materials to be developed. • Requires community-civil society-government-private partnerships to roll out innovative upgrades to existing settlements.
Energy efficiency (e.g., combined heat and power; smart grids, smart cities)	• Capital, operational and maintenance costs are high. • The costs to maintain the system and the availability of existing skills to use the technology could lead to resistance/lack of buy-in. • In cities that are cash-strapped there may be a lack of political support in terms of providing financial support.
Climate adaptive buildings	• Limited low-cost adaptation measures and regulations/codes to enforce implementation of adaptation options. • Limited skilled capacity (engineers, architects and builders, inspectors) to develop standards and to enforce standards. This can increase the difficulty of implementing adaptation measures.

Type of technology or technological system / field	Barriers to technology development and implementation
	• Enforcement procedures of national building regulations and local by-laws are sometimes limited or non-existent within local municipalities. • The availability of suitable materials at an affordable cost.

Table 4-13: Barriers to Settlements-Related Adaptation (CSIR, 2019)

Type of technology or technological system / field	Barriers to technology development and implementation
Heat resilient surfaces (e.g., warm mix asphalt and engineered cementitious composite	• Capital scarcity for long-term capital-intensive investments. • South Africa's investment in R&D has been in steady decline. • The railway capacity is insufficient to support the transportation of large quantities of raw materials and recycled materials needed to produce new types of concrete and asphalt. • High transport and labour costs. • Volatility and low productivity of the workforce. • Shortage of skilled workers that can support the deployment of new concrete and asphalt technologies. • Slag by-product from manganese alloy production is classified as a hazardous material and cannot be sold in South Africa, but could be used in new asphalt mixes

4.3 Climate Change Research and Systematic Observation

South Africa prioritises climate research and systematic observation and this is evident from several institutions which are researching and developing programmes to address research and systematic observation needs. For the climate change research and systematic observation sub-chapter, the following topics are covered:

- South Africa's Policy on funding of Climate Change Research and Systemic Observation,
- Climate Observation and Research institutions and programmes,
- Climate process research and climate system studies,
- Constraints and specific financial, technical and institutional needs for capacity-building on research, systematic observation and early warning systems.

4.3.1 South Africa's Policy on Funding of Climate Change Research and Systemic Observation

The South African government is committed to supporting systemic and observation research. The National Development Plan (NDP), which outlines the country's strategy for research and development, reflects this commitment (NPC, 2011). The NDP seeks to ensure that South Africa is able to conduct leading research and to encourage using that knowledge to guide public policy. The South African government has established a number of financing mechanisms to encourage and support systemic observation and research (DSI, 2022).

This is disbursed via various research institutions and councils in the country, including the National Research Foundation, the Department of Science and Technology, the Department of Higher Education and Training, the Council for Scientific and Industrial Research and the Agricultural Research Council (DSI, 2022). Universities and other groups that are engaged in research are also given grants and other forms of financial assistance by the government for this purpose. In addition,

financing for research and systematic observation in the country is provided for by the private sector and non-governmental groups.

Government spending for Scientific and Technology Activities (STA) as a percentage of the entire national budget is shown in the time series in Figure 4-2 below, which figure provides a time series of the ratio of government funding for STA to total national government budget, illustrating its decline from 2016/17 through the 2021/22 fiscal year to the medium term (2022/23 to 2024/25).

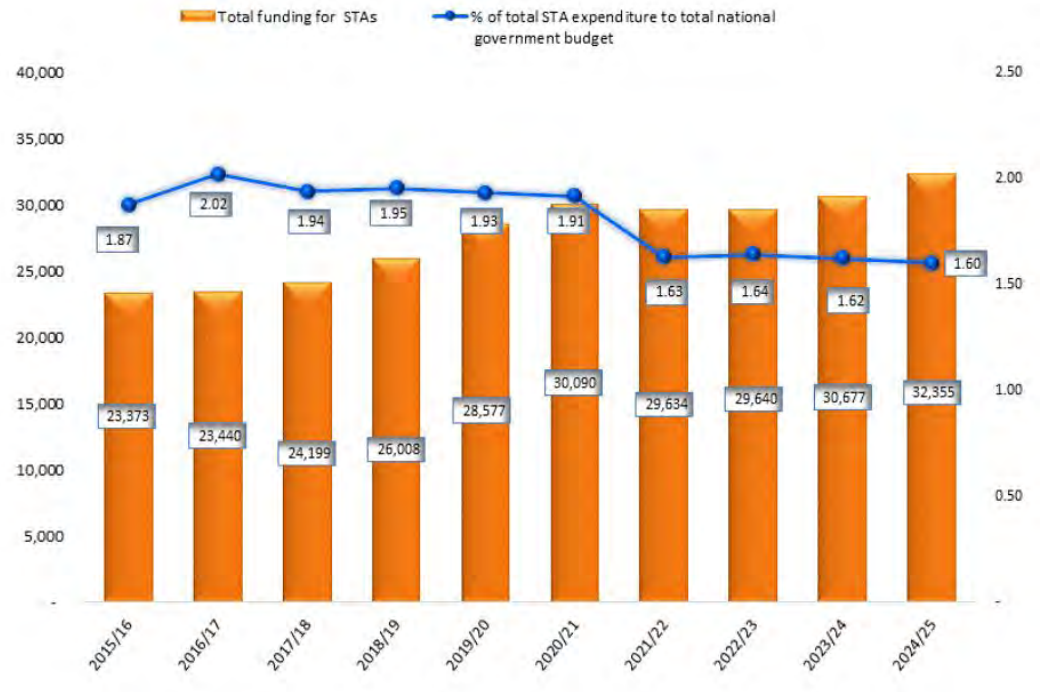

Figure 4-2: STAs total funding for from 2016/17 to 2024/25

STAs cover a range of activities, including the generation, diffusion and use of scientific and technological knowledge and activities for building and exploiting scientific and technological capabilities. The government funds not only research and development (R&D) but also scientific and technical education training (STET) and scientific and technical services (STS). The scope of the government's role covers funding public research institutions (PRIs) and R&D programmes, investing in modernising research infrastructure, growing the high-level human capital base, funding technology transfer activities and specialised scientific facilities (e.g., laboratories) that support service delivery, providing incentives to encourage business sector R&D and innovation and leveraging international STI resources.

Various components of government play different but interconnected roles in STAs. The Department of Science and Innovation, due to its mandate, contributed the most (29%) to total government funding for STAs in 2021/22. Other STI-intensive departments that made significant contributions towards STA funding were Higher Education and Training (14%), the South African Police Service (13%), Mineral Resources and Energy (6%), Health (6%), Basic Education (6%), Agriculture, Land Reform and Rural Development (5%), the National Treasury (4%), Environment, Forestry and Fisheries (3%) and Small Business Development (2%). Collectively, these 10 departments contributed about 88% of total STA funding in 2021/22 (see Table 4-14).

Table 4-14: Top 10 STA-funding departments by percentage contribution to total government STA funding in 2021/22

Department	STA Funding 'R'000	Total Departmental Budget R'000	% Contribution to Total STA Funding
Science and Innovation	8 625 919	8 933 315	29.11%
Higher Education and Training	4 196 233	115 596 900	14.16%
Police	4 067 099	96 355 500	13.72%
Mineral Resources and Energy	1 893 111	9 180 800	6.39%
Health	1 870 295	62 543 300	6.31%
Basic Education	1 720 158	27 018 100	5.80%
Agriculture, Land Reform and Rural Development	1 418 001	16 920 400	4.78%
National Treasury	1 229 217	849 230 100	4.15%
Environment, Forestry and Fisheries	942 636	8 716 800	3.18%
Small Business Development	850 927	2 538 300	2.87%

Data Note: The sum total of STA funding in 2021/22 was R29.6 billion from 34 national departments out of a total departmental budget of R1.81 trillion.

These funds were mostly allocated to research entities, higher education institutions and private sector consultants (DSI, 2022), which include the South African Medical Research Council, the Department of Science and Technology and the National Research Fund (NRF) (SAMRC). The DST and the SAMRC sponsor research in particular fields like health and technology, whilst the NRF provides financial support for research programmes. A number of research institutes have also been founded by the South African government, including the South African Institute for Advanced Research (SAIAR), the African Institute for Mathematical Sciences (AIMS) and the South African National Space Agency (SANSA). These research institutes are in charge of assisting with research and development in their corresponding domains. Lastly, a variety of programmes have been implemented by the South African government to encourage research and observation. The National System of Innovation, the National Research Foundation Act and the National Integrated Science Plan are a few examples. These programmes aim to develop a dynamic research and observation system in South Africa that is able to generate top-notch research that can influence public policy.

4.3.2 Climate Observation, Research Institutions and Programmes

The South African government has made large investments in research on the climate system and climate process, including paleoclimatic studies, general circulation models, modelling and prediction and general climate change research. Further, the country is committed to building a comprehensive climate observing system to support climate change monitoring, research and adaptation. It has undertaken several initiatives to develop a national climate observation system, as well as to ensure the long-term continuity of data, data quality control and availability as well as the exchange and archiving of data. Below includes the mandates and objectives of climate observation and research institutions and programmes, including:

- The South African Environmental Observation Network (SAEON),
- The South African Weather Service (SAWS),
- The South African National Space Agency (SANSA),
- The Council for Scientific and Industrial Research (CSIR),
- The South African National Biodiversity Institute (SANBI),
- The Council for Geoscience, Agricultural Research Council, and

- South African Universities.

4.3.2.1 South African Environmental Observation Network

The South African Environmental Observation Network (SAEON) is a research platform funded by the Department of Science and Innovation (DSI) and managed by the National Research Foundation (NRF). SAEON facilitates and conducts research through platforms and these have grown into a diverse array of sites, instruments, infrastructure, datasets, models and staff, which are widely distributed across both marine and terrestrial environments. SAEON platforms enable researchers to conduct research that is critical for detecting, understanding and predicting environmental change. These platforms are very diverse, providing data from terrestrial, freshwater and marine ecosystems, from sites ranging in size from a few hectares to hundreds of square kilometres. One of the current climate change initiatives undertaken by SAEON is developing the National Climate Change Response Database, in collaboration with the DFFE. This project aims to initiate a dialogue with the world about South Africa's mitigation and adaptation strategies to fend off and protect against the ever-encroaching threat of climate change. SAEON's mandate in this project is to make sure that this important dialogue is supported by great technology.

4.3.2.2 South African Weather Service

The South African Weather Service (SAWS) was established in accordance with the South African Weather Service Act (Act No 8 of 2001), which aims to provide useful and innovative weather, climate and weather-related products and services. SAWS does this by enhancing observational data and communications networks, effectively developing and managing talent in the sector, enhancing collaborative partnerships and effectively disseminating weather service products to the users, utilising cutting-edge technology to convert data into meaningful products and services for risk mitigation, advancing the science of meteorology, undertaking research and relevant applications and enhancing fiscal discipline and resource mobilisation to ensure sustainability.

SAWS collates, maintains and runs a quality control process of South Africa's meteorological and climatological data and related information. This archived data consists of daily rainfall values since 1836, daily surface observations for all stations, but for selected stations since 1884, hourly data of wind direction, wind speed, temperature, humidity, pressure and sunshine from 1950 onwards, upper-air sounding data since 1961, marine data from 1975 on-wards and forecasting data since 1990, satellite data since 1992 and radar data since 1994.

In terms of climate change, SAWS is interested in ways to downscale the possible effects of global climate change and to determine impacts on local scales. These impacts will be important to guide SAWS on ways to evolve its services and the types of systems required to deliver these services. One of SAWS' programmes is the Climate Change Reference Atlas which aims to create an accessible climate basis for national and local scale climate change impacts, adaptation and response planning and which addresses general assumptions about climate change in a localised, scientific manner. The institution also works around the early warning service where it undertakes R&D services to enhance early warnings of weather hazards over all time scales.

Other programmes of SAWS include the provision of weather data to the aviation and other industries via an operational weather observing system. In order to provide local real-time monitoring of atmospheric climate conditions, SAWS has set up a dense network of Automated Weather Stations (AWS) throughout the country (SAWS, 2022) with an average infrastructure availability of 83.14%. Lastly, the South African Weather Service's National Lightning Detection Network, which offers lightning detection information in almost real-time, is a supplement to the AWS network. An active radiosonde network has also been set up in South Africa to offer upper-air climate observations.

4.3.2.3 South African National Space Agency

The South African National Space Agency (SANSA), a division of the DSI, was created to oversee the research, development and use of satellite-based technologies (National government, 2022). Notably, it has been mandated to provide space-related services and products to the country's citizens and those in the nearby region, namely: to support, direct and conduct research and development in space science and engineering, as well as practically applying the innovations they produce; to increase interest in science and build human capacity in space science and technologies in South Africa and to foster an environment that encourages industrial development.

SANSA has been actively involved in conducting research on past climate change and its impacts on conditions today. An example of this is Earth Observation Satellite data maps that SANSA provided to aid authorities and businesses in the Eastern Cape Province. These maps were developed to aid disaster response efforts and to quantify the damage caused by floods (SANSA, 2023). SANSA also developed disaster management tools that can provide relevant authorities with early warning of floods and information on high-risk flooding areas. SANSA also has a capability to monitor flooding and provide authorities with relevant satellite imagery to assist with post flood disaster management.

4.3.2.4 Council for Scientific and Industrial Research

The Council for Scientific and Industrial Research (CSIR) is a leading scientific and technology research organisation that researches, develops, localises and diffuses technologies to accelerate socioeconomic prosperity in South Africa. The CSIR was established through an Act of Parliament in 1945 and the organisation’s executive authority is the Minister of Higher Education, Science and Innovation.

The CSIR has a climate services unit (Climate Services Group) which contributes to holistic climate change research. It serves as an important link with industry, as it undertakes directed climate change research that supports sectoral and integrative climate change responses with tangible impacts for low-carbon, resilient industries and development across southern Africa. Specifically, the group provides analysis of climate change risks, climate change impacts and potential responses to climate change across sectors. Services and products provided include crop modelling, species distribution modelling, agro-hydrological modelling, greenhouse gas (GHG) inventory calculations, low-emission strategies, resource constraints trade-offs and reporting on progress towards meeting the country’s commitments to the United Nations Framework Convention on Climate Change. The group uses decision-support tools, information and communication technologies such as spatial information systems, geographical information systems, web mapping systems dynamics and remote sensing. The group works in various sectors, including human health, biodiversity, water, energy, human settlements, agriculture, transport and industrial processes and product use.

The key research and solutions provided to the market include investigations, assessments, trade-off analysis, decision-making support, policy formulation and planning in the following areas:

- *Climate change impact studies for industries and key socioeconomic sectors*: Climate change projections are used in high-resolution impact models (such as water and agriculture in urban and rural areas) to understand the risks and vulnerabilities facing the industries and sectors to develop targeted adaptation strategies. Tailor-made information products using the climate data are used to generate support for climate science communication and dissemination (climate services) especially in a data and technology constrained environment.
- *GHG emission inventories and carbon modelling*: The group provides support to industries and government in developing a complete and transparent GHG emissions inventory that is used as a basis for developing GHG trajectories and identifying key mitigation options. Furthermore, the group produces detailed estimates of land use impacts on terrestrial carbon stocks. This information is important to municipalities and farmers as they can use it in the future as part of their response strategies to carbon accounting and carbon taxes.

- *Climate change co-benefits and technology prioritisation*: The group considers the assessment and prioritisation of technologies related to climate change as an integral step in supporting synergistic adaptation and mitigation responses. This is because such information highlights co-benefits (such as environmental benefits, reduction in GHG emissions and improved livelihoods) in terms of the planning and implementation of climate responses.
- *Monitoring and reporting of climate change interventions*: The group supports the understanding of the impact of the country's role in contributing to achieving the goals of the Paris Agreement and the extent to which these actions translate into environmental and socioeconomic transformations that support sustainable development in the country.

4.3.2.5 South African National Biodiversity Institute

The South African National Biodiversity Institute (SANBI) was established on 1 September 2004 in terms of the National Environmental Management: Biodiversity Act (Act No 10 of 2004). The mandate of SANBI is to play a leading role in South Africa's national commitment to biodiversity management, now and into the future. In partnership with DEA (currently the DFFE) and the biodiversity sector, SANBI is tasked with leading the biodiversity research agenda. This institution provides knowledge and information, policy support and advice, it manages gardens as windows to our biodiversity for leisure, enjoyment, spiritual upliftment and education and engages in ecosystem restoration and rehabilitation programmes using best practice models to manage biodiversity better.

Research is central to SANBI's agenda and, as such, it will continue leading the research agenda relating to climate change and bio-adaptation. The research will be aimed at enhancing climate change policy development and decision making by increasing access to appropriate scientific knowledge, in an attempt to increase the participation of previously disadvantaged individuals in biodiversity.

Some of the climate change programmes undertaken by SANBI include:

- The Small Grants Facility (SGF) whereby SANBI has successfully supported twelve community-based organisations to develop and implement projects aimed at building resilience to climate change impacts through its Small Grant Facility's (SGF's) project which ran from 2015 to 2021. The SGF programme delivered a range of tangible local benefits for 1 921 direct and 9 006 indirect beneficiaries through implementing projects under the following themes: climate-resilient livelihoods, climate-smart agriculture and climate proof settlements.

- The Groen Sebenza Climate Change Adaptation Project, which is aimed at developing capacity in the climate change adaptation space, was primarily implemented in provinces and national sector departments to enable them to better respond to climate change adaptation challenges within their contexts. The project aims to pair unemployed graduates primarily from previously disadvantaged backgrounds with experienced professionals to learn, grow and eventually gain the competence and confidence to embark on rewarding and meaningful careers in climate change adaptation.

- Lastly, the South African Case Study on Climate Change and Biodiversity Planning is a paper which focuses on how the Map of Critical Biodiversity Areas and Ecological Support Areas (CBA Map) incorporates most of the climate change mitigation and adaptation areas. It also includes how it can be integrated into municipal spatial development frameworks and land use management schemes.

4.3.2.6 The Council for Geoscience

The Council for Geoscience (CGS) is one of the National Science Councils of South Africa and is the legal successor of the Geological Survey of South Africa, which was formed in 1912 by the

amalgamation of three former surveys, the oldest of which - the Geological Commission of the Cape of Good Hope - was founded in 1895. The Geoscience Act, No. 100 of 1993 established the CGS in its present form. Today, the CGS is a modern institution which boasts excellent facilities and expertise and ranks among the best in Africa. The objectives underlying the establishment of the CGS are to develop and publish world-class geoscience knowledge products and to render geoscience-related services to the South African public and industry.

The second fixed mandate under which the CGS operates forms part of the National System of Innovation, as stated in 'South Africa's National Research and Development Strategy' of 2002 as defined in the White Paper on Science and Technology of 1996 where the Department of Science and Technology plays an integrative role in regulating science and technology across all State-owned research organisations. The third mandate that the CGS operates under is that which is expressed in the speeches and addresses made by, for example, the President of South Africa in his State of the Nation address and the various budget-vote speeches made by the Ministers of Minerals and Energy and of Science and Technology.

One of the climate change projects undertaken by the institution is the new carbon capture and storage project. The capture and storage of carbon dioxide (CCS) has been identified as one of the fundamental approaches to mitigating global climate change and CGS has been at the forefront of CCS innovation since 2010 and has produced an atlas on the geological storage of CO_2 in South Africa.

This atlas identified possible onshore and offshore repositories within South Africa conforming to the prerequisites for CCS. Since the publication of this atlas, work has focused on three potential storage basins within South Africa, namely the onshore Zululand and Algoa Basins and the offshore Durban Basin. In 2016, a project was set to initiate, focusing on the potential for site monitoring at the Bongwana natural CO_2 gas release near Harding in KwaZulu-Natal.

4.3.2.7 Agricultural Research Council

The Agricultural Research Council (ARC) is a premier science institution that conducts research with partners, develops human capital and fosters innovation to support and develop the agricultural sector. The ARC was established in 1990 through the Agricultural Research Act 86 of 1990 (as amended by Act 27 of 2001) and is the principal agricultural research institution in South Africa. It is a schedule 3A public entity in terms of the Public Finance Management Act 1 of 1999, (as amended by Act 29 of 1999).

Its core mandate, as defined in the Act, is to act as the principal agricultural research institution in South Africa so as to conduct research, drive research and development, drive technology development and the transfer of information in order to:

- Promote agriculture and related industries;
- Contribute to a better quality of life;
- Facilitate/ensure natural resource conservation; and
- Alleviate poverty.

The ARC undertakes and promotes Climate-smart agriculture (CSA), which is an approach that helps to guide the actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate. CSA aims to tackle three main objectives: sustainably increasing agricultural productivity and incomes, adapting and building resilience to climate change and reducing and/or removing greenhouse gas emissions, where possible. The ARC provides training programmes for extension practitioners to provide an opportunity for them to learn about CSA and how it applies to the farmers that they serve.

4.3.2.8 Universities

The government has been working with universities and other research institutions to develop and strengthen existing research and knowledge on paleo-climatic studies, modelling and prediction (Bopape *et al*., 2019). These efforts have been essential in informing policymakers of the potential risks posed by climate change and informing the public of the importance of taking proactive steps to mitigate and adapt to the impacts of climate change.

These universities include:

- University of Cape Town: Climate System Analysis Group

The Climate System Analysis Group (CSAG) is a leading international climate research centre based at the University of Cape Town with broad research skills and competency in both the physical and social dimensions of climate, a strong experience in engaging with society and an excellent track record in capacity development. They prioritise societally relevant research to support responses to climate variability and change.

- Stellenbosch University: School for Climate Studies

Stellenbosch University (SU) launched a new School for Climate Studies in 2021. This is the first school of its kind in South Africa that has the status of a faculty. The school creates transdisciplinary capacity to combine the climate-related knowledge systems of the University's faculties, the public sector's climate policies and initiatives, the private sector's climate redress and innovation capacities and the social impact mission of SU in both academic and applied ways – all in support of the transition to a climate-resilient society and a sustainable, low-carbon economy.

- Wits University: Global Change Institute

The Global Change Institute (GCI), formerly known as the Global Change and Sustainability Research Institute) was established as an enabling research platform of global significance and local impact, fostering informed action for adaptation and innovation in the rapidly changing southern African region. The GCI addresses problems related to global change, climate change and sustainability in a multidisciplinary and transdisciplinary manner. The GCI wants to play a more prominent role in helping to co-create, understand and inform global change solutions at various levels of decision-making (in business, industry and government – municipal, provincial, national) and to function as an enabling platform utilising research to support progressive change through collaborative efforts with stakeholders.

4.3.3 Climate Process Research and Climate System Studies

The national government has undertaken several initiatives to strengthen its climate process and climate system studies, including paleo-climatic studies. These include the Climate Change Information System (CCIS) which is part of the national effort to track South Africa's overall transition to a low carbon and climate resilient economy as required by the National Development Plan (Vision 2030) and the NCCRP (2011), as well as South Africa's 2015 NDC to the UNFCCC. The Government has a wide variety of tools, which include:

- Agricultural Research Council news and articles: The ARC reports on general information around agricultural topics including but not limited to country-specific information agricultural infrastructure engineering, agricultural structures and facilities, agro-processing, conservation agriculture, food security, irrigation and drainage, mechanisation and precision agriculture, renewable energy and structures and facilities.
- The South Africa Biennial Update Report Explorer: This platform offers open data, visualisations and analysis to help one gather insights into South Africa's climate progress. It is an important part of the National Climate Change Monitoring and Evaluation (M&E)

System established as part of the national efforts to track South Africa's overall transition to a low carbon and climate-resilient society and economy.

- Bioenergy Atlas for South Africa: A repository of information, tools and data supporting the bioenergy industry in South Africa.
- Carbon Disclosure Project: The CDP is a not-for-profit organisation that runs the global disclosure system for investors, companies, cities, states and regions to manage their environmental impacts. The world's economy looks to CDP as the gold standard of environmental reporting with the richest and most comprehensive dataset on corporate and city action.
- Carbon Sinks Atlas: A GIS and Data Portal for the South African Environmental Observations Network.
- Climate Change Knowledge Portal: An online portal to explore historical and projected climate data, climate data by sector, impacts, key vulnerabilities and what adaptation measures are being taken.
- Climate Information Portal (CIP): A web interface that integrates two important information sources into one easy to use interface. The portal's source is a climate database that stores and manages queries to a large suite of observational climate data, as well as projections of future climate.
- Climate Risk Adaptation Framework and Taxonomy (CRAFT): A C40 Cities initiative which helps the mayors and cities lead in taking ambitious, collaborative and urgent climate action that aligns with science-backed targets. It allows them to work together across borders in order to protect people and communities everywhere and build a more sustainable, resilient and equitable future.
- DEA Coastal Viewer: A spatial data viewer relating to the Coastal Zone available to the public. The data is sourced from the relevant custodians to inform decision making processes focusing on the sustainable use of coastal resources and promoting coastal management objectives as described in the National Coastal Management Programme of South Africa.
- Environment & Health Research Unit: A unit from the South African Medical Research Council (SAMRC) established in 1969 which is dedicated to improving the health of people in South Africa through research, innovation, development and technology transfer. The scope of research includes laboratory investigations, clinical research and public health studies, including climate change.
- Flow Tracker App: an App developed for the Olifants River. It enables near real-time flow and dam monitoring and includes a weather forecast facility. It is designed for use by residents to improve catchment awareness.
- GreenBook: An online planning support tool that provides quantitative scientific evidence on the likely impacts that climate change and urbanisation will have on South Africa's cities and towns. It also presents a number of adaptation actions that can be implemented by local government to support climate-resilient development.

- HST Health Indicators: Present the best available data on a wide range of health and related indicators. This provides health planners and managers with easy access to data from a variety of sources.
- ICLEI Carbon Climate Registry: A portal by the ICLEI – Local Governments for Sustainability, a global network of more than 2 500 local and regional governments committed to sustainable urban development.
- Let's Respond Toolkit: A tool used to integrate climate change risks and opportunities into municipal planning.
- Mine Water Atlas: A comprehensive reference on the vulnerability of water resources to mining activities in South Africa. It shows the critical interplay between mining and water resources and is the most extensive set of documents of its kind.
- National Environmental Screening Tool: The National Web based Environmental Screening Tool is a geographically based web-enabled application which allows a proponent intending to submit an application for environmental authorisation in terms of the Environmental Impact Assessment (EIA) Regulations 2014, as amended, to screen proposed sites for environmental sensitivities.
- National Integrated Water Information System (NIWIS): The information system was developed by the Department of Water and Sanitation with the purpose of providing information products in the form of dashboards to facilitate efficient analysis and reporting across the water value chain in South Africa.
- NDMC Disaster Atlas: This tool presents historic records of declared or gazetted disasters.
- Poverty Stoplight SA: A tool that seeks to activate the potential of families and communities to lift themselves out of poverty. Using a technology platform, it offers a self-assessment survey and intervention model that enables people to develop practical solutions to overcome their specific needs.
- REGIONSADAPT (Region 4 Sustainable Development): A global voice of regional governments (states, regions and provinces) before UN negotiations, European Union initiatives and global discussions in the fields of climate change, biodiversity and sustainable development.
- SA 2050 Pathway Calculator: A tool that can be used to engage technicians, policy makers and the general public on how the country’s emissions could change overtime. Because it is open-source and easy to use, the tool makes it possible for anyone to explore the combinations of efforts to reduce emissions while matching energy supply and demand.
- South African Air Quality Information Systems (SAAQIS): The information system provides a common platform for managing air quality information in South Africa. It makes data available to stakeholders including the public and provides mechanisms to ensure uniformity in the way air quality data is managed i.e., captured, stored, validated, analysed and reported on in South Africa.
- South African Risk & Vulnerability Atlas (SARVA): An initiative of the Department of Science and Innovation and forms a 10-year Global Change Grand Challenge. It is currently in its third phase of implementation with this phase focusing on improved access

to ecological, economic, human and settlement data and the development of decision-support tools that assist with evaluating and managing the risks associated with global change.

- Smart Home: A tool to help reduce water and electricity use at household level by advising on how to make a few small adjustments.
- South African Atmospheric Emission Licensing and Inventory Portal (SAAELIP): An online portal for the management of Atmospheric Emission Licences (AEL) as well as the estimation and reporting of atmospheric emission inventories in terms of the National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004). SAAELIP provides a seamless integration between the management of Atmospheric Emission Licences and the reporting of atmospheric emissions into the National Atmospheric Emission Inventory System (NAEIS).
- South African Waste Information System (SAWIS): Developed by the DEA in 2005, SAWIS is a system used by government and industry to capture routine data on the tonnages of waste generated, recycled and disposed of in South Africa on a monthly and annual basis.
- The Redbook Neighbourhood Planning and Design Guide: A guide which provides practical information related to the planning and design of a range of services and infrastructure typically provided as part of neighbourhood development projects. The application of the guidelines ultimately results in the delivery of infrastructure and services that are effective and efficient and that contribute to the creation of sustainable human settlements.
- Water Research Commission's Drought SA Web Portal: A unique online drought portal that provides visitors with useful information on current droughts and links to various other drought-related websites. The Drought SA portal will be an ongoing project and will be continuously populated with fresh research and knowledge that will empower visitors.

4.3.4 Constraints and Specific Financial, Technical and Institutional Needs for Capacity-building on Research, Systematic Observation and Early Warning Systems.

South Africa has a number of research programmes related to climate change, but there are some significant constraints and gaps. One significant barrier is finance (Ziervogel et al., 2022). The cost of conducting climate change research prevents South Africa from conducting it at a comparable level to that of other nations. As a result, there are fewer research projects that can be carried out in South Africa and there is a shortage of data and information about the effects of climate change in the region. The absence of capacity and knowledge in the area is another restriction. Moreover, there are not many organisations and researchers in South Africa working on climate change research and they frequently struggle to keep up with the most recent developments in the field (ASSAf, 2019). As a result, developing strategies to combat climate change has not been done using evidence-based decision-making. The lack of public interest and involvement in climate change research is a third barrier.

The effects of climate change and the necessity for research to comprehend these implications and develop solutions are not well known in South Africa. The development of public policy to address climate change has been hampered by this.

In South Africa, there is a lack of coordination among the various research institutions and programmes (Razzano, 2016), which has prevented the development of successful strategies to combat climate change and has resulted in a lack of research integration. To ensure that South Africa is able to successfully meet the issues brought on by climate change, it is necessary to overcome these limitations and gaps in the nation's climate change research programmes. Table 4-15 provides constraints and gaps identified in the financial, technical and institutional needs for capacity-building.

Table 4-15: Constraints and gaps identified in research, systematic observation and early warning systems

Category	Constraints
Financial	The financial resources available to South Africa to fund research, systematic observation and early warning systems are insufficient. Recommendations: More public financing is required for these fields in South Africa to strengthen the country's capacity in this sector and in order to increase the country's capacity in this area, South Africa must entice private sector investment in these fields of research, systematic observation and early warning systems.
Technical	Due to a lack of trained personnel and the complexity of the required equipment, South Africa faces technical problems in building and maintaining current arrangements for research, systematic observation and early warning systems. Recommendations: 1. Training and capacity development: To make sure that the country has the necessary competence to establish and sustain these systems, South Africa must invest in training and capacity building for these fields. 2. Infrastructure: To guarantee that the country has the means to support these systems, South Africa must invest in the infrastructure required for research, systematic observation and early warning systems.
Institutional	Universities and other South African institutions lack the necessary resources to address the needs of the nation in terms of research, systematic observation and early warning systems. Recommendations: 1. Inter-institutional collaboration: To strengthen the country's capabilities in these fields, South Africa must encourage inter-institutional cooperation. 2. Establishing a legislative framework is necessary in South Africa to guarantee that research, systematic observation and early warning systems are created and maintained in accordance with international norms.

4.4 Climate Change Education Training and Public Awareness

According to Maponya and Lotz-Sisitka (2022) South Africa has a moderate level of general awareness and understanding of issues related to climate change and policies regarding climate change education, training and public awareness. As part of its efforts to raise public understanding of climate change, the government has started public awareness campaigns and funded climate change education programmes. These include: the National Climate Change Response White Paper, which details the government's objectives for adapting to and mitigating climate change and is one example of how the government has been concentrating on implementing climate change laws and regulations. The Chief Directorate for Climate Change Monitoring and Evaluation serves as South Africa's UNFCCC Action for Climate Empowerment (ACE) Focal Point in the DFFE (Maponya and Lotz-Sisitka, 2022). The Chief Directorate closely collaborates with the Department's units for Education, Training and Development Practices to increase public understanding of climate change and host capacity building initiatives. Additionally, SANBI is designated with the primary responsibility of developing capacity and offering policies about biodiversity and climate change adaptation (SANBI, 2019). The Institute is assisting South Africa in achieving a Just Transition to a low carbon economy and resilient society in its capacity as an accredited entity of the Adaptation Fund and Green Climate Fund.

In terms of climate change and communication, there are a number of departments that have been championing and mainstreaming climate change education (Maponya and Lotz-Sisitka, 2022), as shown in Table 4-16.

Table 4-16: Climate Change Communication Departments

Department	Role
Department of Basic Education	is responsible for pre-primary, primary and secondary education and promotes environmental and climate change education across a variety of grades and subjects.
Department of Higher Education and Training	has responsibility for ensuring that knowledge of climate change is incorporated into post-secondary education and training courses (including Technical and Vocational Education and Training, Community Colleges and Universities). The Department of Science and Innovation funds its research mandate, which also supports research at South African universities.
Department of Science and Innovation	focuses on the inclusion of research related to innovations in energy, global change (which includes climate change), food security, health, water and green economy development, all of which includes a focus on green skills acquisition.

The requirement for greater collaboration and engagement between government agencies working on scientific and practical responses to climate change, including between the Departments of Environment, Forestry and Fisheries, Science and Innovation, Basic Education and Higher Education and Training, is strongly emphasised by the country (DEFF, 2020).

Such an example is seen from research partnerships with the National Research Foundation's South African Research Chairs Initiative, Communities of Practice and Centres of Excellence research initiatives and partnerships and collaborations in national research entities such as the ARC, the Water Research Commission and the CSIR are examples of collaboration seen from the DSI that is supporting the development of high-level green skills in climate change.

4.4.1 National Curriculum and the Efforts Made by the Government

The 2011 National Curriculum and Assessment Policy Statement integrates elements of environmental education and climate change education into various subjects at primary and secondary education levels, including natural science, social science, life orientation and economic and management sciences. However, this integration lacks a clear progression or coherent alignment with the national policy direction on climate change (Maponya and Lotz-Sisitka, 2022).

In higher education, the 2010 Global Change Grand Challenge National Research Plan emphasises research in earth systems science, ecological footprint reduction, sustainability adaptation and innovation. This plan is the result of the Department of Science and Technology's Ten-Year Innovation Plan, introduced in 2008. In the same year, a national plan for research into alternative energy sources and the Energy Grand Challenge was also introduced.

Furthermore, the DSI's 2021 Global Change Social Sciences Research Plan focuses on sustainability-related changes. It includes themes related to education, such as the development of green skills for a Just Transition and transformative, transgressive social learning.

Lastly, a strategic goal related to improving "education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning" is included in South Africa's education sector plan, Action Plan to 2024, which was published in 2020 (DBE, 2020).

The 2011 National Curriculum and Assessment Policy Statements stipulates that climate change education is to be incorporated into curricula for pre-primary, primary and secondary education using a topic-based approach. Further, the Plan acknowledges that "Climate change is something for which the schooling system must prepare, through measures to mitigate impacts and through the education of teachers and learners of the issues" (i.e., some school subjects have topics related to climate change).

Table 4-17 below, provides the efforts undertaken to address the inclusion of climate change into the education and training in the country.

Table 4-17: Efforts made per education levels in South Africa (Maponya and Lotz-Sisitka, 2022)

Education level	Efforts made
Pre-primary education	"The 2018 National Curriculum Framework: For Children from Birth to Four" is divided into early learning and development topic areas, one of which is called Knowledge and Understanding the World. This topic area includes content on climate and weather taught across different learning activities appropriate for this level of education. For example, learning activities encourage students to explore their world and understand the relationship between themselves and their environment, including the atmosphere.
Primary and secondary education	The 2011 national Curriculum and Assessment Policy for Basic Education (Grades 1-12) uses a topic-based approach. At the primary level, the revised 2012 Curriculum Assessment Policy Statement (CAPS) for Senior Phase (Grades 7-9): Social Science has topics on the natural environment, climate and vegetation, which are also included in other subjects, such as Natural Science. At the secondary level, the 2011 Curriculum Assessment Policy Statement for Further Education and Training Phase (Grades 10-12): Geography has topics, such as water resources, resource sustainability, climate and weather, with content that encourages students to think about their own behaviours concerning the environment.
Teacher training and teacher resources	The National Policy Framework for Teacher Education and Development in South Africa (2006) acknowledges that threats to the environment are one of South Africa's most significant challenges. The Framework also states that schools must respond directly to environmental threats by preparing children to understand and address these challenges and that "teacher education, including continuing professional development, has the vital role of equipping teachers to undertake this task".
Higher education	Climate change education research is usually included in South African higher education institutions in relation to the energy and global change challenges research programmes and green (environment-friendly) skills development. This focus includes a forward-thinking national research plan which focusses on both energy and on 'Global Change,' challenges, which addresses climate change from a sustainability innovations perspective.
ABET adult learning	The Department of Higher Education and Training particularly focuses on Technical and Vocational Education and Training (TVET) and Community Education. In the case of TVET, the Department recognises the importance of providing youth with the skills to participate in a green (environment-friendly) economy and has established partnerships with the GIZ to support development of Green TVET models and curricula. Similarly, the Department focus on Community Education and recognises the importance of adult learning in climate change actions.

The 2010 Global Change Grand Challenge National Research Plan and the Global Change Social Sciences Research Plan for 2021 both support research in higher education at several South African

universities. The 2021 Research Plan places a stronger emphasis on research pertaining to the environment and sustainability, including innovation and adaptation in sustainability through transdisciplinary research and methods. The South African National Energy Development Institute (SANEDI) is also supporting a coordinated research programme on energy alternatives. The Energy Grand Challenges Research Plan also features a substantial and well-connected system of research, with a number of research Chairs and Centres of Expertise.

4.4.2 Information on the Implemented or Planned Public Information Initiatives, Campaigns and Programs on Climate Change

SANBI is implementing community initiatives to raise awareness of the impact of climate change on biodiversity (SANBI, 2022). The initiatives take the form of National Biodiversity Gardens and there are currently six of them across the country:

- Pretoria National Botanical Garden.
- Walter Sisulu Botanical Garden.
- Lowveld National Botanical Garden.
- KwaZulu-Natal National Botanical Garden.
- Kirstenbosch National Botanical Garden.
- Karoo Desert National Botanical Garden.

4.4.3 Available Information on the Implemented or Planned Training Programmes on Climate Change

A range of training programmes on climate change are available in South Africa (Maponya and Lotz-Sisitka, 2022), including:

- The Climate Change Awareness Programme of the SANBI, which aims to educate teachers on the effects of climate change and how to address them in the classroom.
- The Climate Change Teacher Training Program offered by the Department of Science and Technology (DST), which equips educators with the knowledge and skills needed to teach about climate change.
- The online Climate Change Course for Educators offered by SAEON, which aims to give teachers the knowledge and abilities they need to effectively teach climate change in the classroom.
- For in-service training, a consortium of partners, led by the Department of Environmental Affairs (DEA), currently the DFFE and the South African National Biodiversity Institute and includes teacher education institutions and environmental sector partners, which developed a teacher education development program called Fundisa [Teaching] for Change in 2010. This program represents a concerted effort to coordinate and set standards for education in sustainable development through accredited programmes that are also endorsed by the South African Council of Educators (SACE).
- The Environmental Learning Research Centre at Rhodes University (formerly the Environmental Education and Sustainability Unit) developed a Teacher Education Workbook for Environment and Sustainability Education in 2009 to fill a gap in the country's curriculum. The workbook is a precursor to the Fundisa for Change programme and discusses climate change in relation to biodiversity, pollution, water conservation, energy and food security.

Maponya and Lotz-Sisitka (2022) revealed that in South Africa, a number of universities have climate change education institutes and programmes. These programmes are primarily financed by the country’s Department of Science and Innovation or National Research Foundation (DSI/NRF). A list of such initiatives is provided below:

- The South African Research Chairs Initiative (SARChI) has a number of researchers who specialise in studying climate change and global change. In particular, research is conducted

and knowledge is developed for climate change education, green skills, transformative learning and social change actions for South Africa and beyond by the SARChI Chair in Global Change and Social Learning Systems, based at the Rhodes University Environmental Learning Research Centre.

- A national Centre of Excellence in Climate and Earth System Sciences, run by the DSI/NRF, is the Applied Centre for Climate and Earth Systems Sciences (ACCESS). Young primary and secondary students are drawn to Earth System Sciences and Sustainability Science subjects, including climate change education, through the innovative trans-disciplinary summer school run by ACCESS. Additionally, a number of creative student-led initiatives are emerging, with ACCESS's Habitable Planet programme being a standout. Students direct the teaching of Earth System Sciences through this curriculum, including tackling problems like climate change from a South African standpoint.
- The Southern Africa Regional Universities Association (SARUA) Curriculum Innovation Network was established in 2014 as a result of research performed on degrees connected to climate change in South Africa. South African universities collaborate through this Network to offer a regional master's degree programme in "climate change and sustainable development for southern Africa." In collaboration with the Southern African Development Community (SADC) Secretariat, the initiative is now being expanded to include instruction and training for policymakers across southern Africa.
- The Climate Change Counts project, another SARUA program, brought together university stakeholders to map research, teaching and outreach capabilities and jointly produce knowledge on national and regional level climate compatible development. One of the project's major findings was the creation of a collaborative research framework to improve knowledge co-production. The study was funded with £288K (US$399K) from the Climate and Development Knowledge Network. With assistance from the SADC Secretariat, this curriculum is currently being transformed into an online course for further adoption within the Southern African Development Community.
- A short course in green skills is being offered to Technical and Vocational Education and Training (TVET) lecturers and managers by the Energy and Water Sector Education and Training Authority and the Environmental Learning Research Centre at Rhodes University. The goal of the course is to increase staff capacity to enhance green skills for TVET students' socioeconomic growth.

4.4.4 Information on Climate Change Information Centres

The primary governmental resource for information on climate change in South Africa is the Department of Forestry, Fisheries and the Environment (DFFE) (Maponya and Lotz-Sisitka, 2022). The Department has taken steps to ensure that the public has access to information about climate change. For instance, the public can download free information about climate change from the Department's website, including project and research reports. In order to synchronise the information on climate change made available to the public, the Department also collaborates closely with statutory organisations including SANBI, the South African Meteorological Service and the South African National Parks. Several programmes run by academic institutions and non-governmental groups seek to guarantee that the general public has access to knowledge about climate change. For example, the Environmental Learning Research Centre at Rhodes University implements various programs, such as Tsitsa Project (a land and water restoration project), Eco-Schools (an environmental learning project), Amanzi for Food (a water research project) and the One Ocean Hub programme, to engage the public in gaining the information and knowledge necessary for sustainable climate change actions.

The DFFE also has the Climate Change Information System (CCIS) which is part of the national effort to track South Africa's overall transition to a low carbon and climate-resilient economy by offering a

series of decision support tools to inform policy and decision-making. The system monitors and evaluates climate change drivers, events, links to national objectives, targets and strategies in respect of climate change mitigation and adaptation monitoring and the assessment of actions taken by stakeholders.

4.4.5 International Cooperation to Promote Education, Training and Public Awareness on Climate Change.

The Department of Higher Education and Training has partnered with the Gesellschaft für Internationale Zusammenarbeit (GIZ; German Organization for International Cooperation) to promote the creation of Green TVET models and curriculum, with a special emphasis on TVET and Community Education. A countrywide green TVET programme has been supported by GIZ for a number of years in order to achieve this. Additionally, they are collaborating with the Education and Training Authority to build up the capacity of green talents for solar and wind energy systems. Moreover, the DFFE offers a Local Government Climate Change Support Programme, widely known as "Let's React," with funding assistance from the GIZ. The programme encourages local municipalities and provincial governments to involve the people in climate action and the programme seeks to increase involvement and partnerships for environmental challenges, including climate change. Also, there is a programme called Driving Force for Change, a prototype youth support programme, which aims to increase youth capacity for resilience and climate change adaptation.

4.4.6 The Gaps, Needs and Priorities in Climate Change Education, Training and Public Awareness

When compiling this section, some of the gaps and needs were around finding information on climate change education in South Africa. The initiatives undertaken to promote climate change awareness are not easy to find as information is scattered, per institution, i.e., to enable systematic upscaling, coordination and extension of climate change education and training efforts, there is a need for improved coordination (Maponya and Lotz-Sisitka, 2022). Greater collaboration and engagement between government agencies working on both scientific and practical climate change responses, such as the Departments of Environment, Forestry and Fisheries, Science and Innovation, Basic Education and Higher Education and Training, are also seen to be necessary. South Africa needs to work on a dedicated strategy for communicating and educating about climate change. There is not yet information regarding the inclusion of climate change content in other subjects, with the climate-resilient development pathway of the National Climate Change Response White Paper not being part of the curriculum. The geography curriculum for Grades 10–12 carries the most substantial content on climate change education in the Curriculum Assessment Policy Statements (CAPS) curriculum. Furthermore, neither climate change nor the problems it raises are particularly addressed in South Africa's National Policy Framework for Teacher Education and Development. There are no policies governing where or how climate change subjects should be integrated in teacher education, which is a concern. Environmental issues are not mentioned in South Africa's Department of Higher Education and Training Strategy Plan (2020-2025). Nonetheless, there isn't much information currently accessible on Climate Change Communication and Education (CCE) policies and practises in many different countries.

4.5 Capacity Building Needs

4.5.1 Capacity Building Needs and Gaps for Developing National Greenhouse Gas Inventories

Several technical and capacity building needs and gaps were identified for the development of the National Greenhouse Gas Inventories. In this section, gaps and needs are provided per type of support (Table 4-18) and per sector (Table 4-19) for South Africa.

Table 4-18: GHG Inventory needs

Types of Support	Activity
Capacity Building	Enhance the capacity to include mitigation actions and activities into the AFOLU inventory.
	Improve capacity to undertake more complete uncertainty analysis on country inventory data for all sectors.
	Build capacity within the inventory team to complete LULUCF emission estimates.
Technical	Enhance technical capacity to develop a land mapping system which allows for the integration of various spatial datasets to inform the land cover matrix.
	Enhance technical capacity for data collection on a regular basis to improve the accuracy of the emission estimates for both waterborne navigation and marine bunkers.
	The availability of accurate activity data and resources e.g., there is still a need to include SF_6 emissions, as well as other gases such as SO_x, NO_x and NMVOC.
Technical and capacity building	Support sector-specific priority data generation processes to improve the GHG inventory. Projects to provide information on country specific emission factors in all sectors, particularly: I. Waste sector. II. Direct and indirect N_2O emission factors for emissions from managed soils and manure management.

Table 4-19: List of planned impro ements for South Africa's in entory per sector

Sector	Improvement	Barriers and constraints
Cross-cutting	Improve uncertainty data for all sectors but incorporate more country specific uncertainty values	Lack of uncertainty data constrains this activity. As data becomes available it will be incorporated, but there are no specific planned projects for this activity at this stage.
	Extend time-series back to 1990 for energy, IPPU and waste sectors.	Lack of data for years prior to 2000, particularly for categories where data is highly variable (such as HFCs and PFCs), have constrained the completion of this task. A study is planned to extend/extrapolate the data back to 1990 for the three IPCC sectors.
	Investigate inconsistencies in lime activity data (for lime production in IPPU and lime application emission in AFOLU), explore alternative data sources or improve consistency.	Not resolved. Various methods were compared but give varying results. Alternative data sources have not yet been found, but it may be possible to collect further data through the SAGERS system in the future.
	Improve QA/QC process by addressing all issues in external review	Challenges in addressing external review comments have been limited by resources and process management. The DFFE inventory team has increased in size which should assist in addressing this issue. There are still a large number of issues not resolved but the inventory

Sector	Improvement	Barriers and constraints
		team is working through them. It is an ongoing process.
	Incorporate NO_x, CO, NMVOC and SO_x emissions	Not resolved. Limited data is available to complete the time series from 2000 – 2020.
Energy	CO_2, CH_4 and N_2O from spontaneous combustion of coal seams	New research will allow this category to be included in the 2021 inventory.
	CH_4 emissions from abandoned mines	New research outputs will enable this activity to be included in the 2021 inventory.
	Fugitive emissions from coke production to be reported separately from 2C process emissions	Progress on this has been slow but reporting through the National GHG Emission Reporting Regulations (NGERs) will allow this activity to be incorporated in the next inventory.
	Incorporate emissions from biogas	This would require a study and shall be recommended as a project under the GHG Improvement Programme (GHGIP).
	CO_2 transport and storage	Proposed but nothing planned.
	CO_2, CH_4 and N_2O emissions from combined heat and power (CHP) combustion systems	Proposed but nothing planned.
	Develop EFs, carbon content of fuels and NCVs of liquid fuels	Resources and funding are required to complete this study so that it may be incorporated into the GHGIP. This study was planned to start in 2020.
	Development of Tier 3 methods for CTL-GTC and GTL	Resources and funding are required to complete this study so that it may be incorporated into the GHGIP.
IPPU	Development of country specific EF for ferroalloy industry	Resources and funding are required to complete this study so that it may be incorporated into the GHGIP.
	Development of Tier 3 methodologies for aluminium production	Resources and funding are required to complete this study so that it may be incorporated into the GHGIP.
	Include emissions from electronics industry	A study needs to be undertaken to understand emissions from these sources, thus it should be highlighted as a project for the GHGIP.
	Incorporate emissions SF_6 emissions	Lack of data is still a challenge.
AFOLU	Improve manure management data, including biogas digesters as a management system	This may be a proposed project as there is high variability in this dataset.
	Incorporate organic soils study to include emissions from organic soils	Not resolved. Due to the other more pressing issues relating to land, this was not a priority and will be incorporated once the land mapping system is operational.
	Complete an assessment of crop types and areas and investigate	Variability in crop classifications from the various data sources have made this challenging. Funding will be required to

Sector	Improvement	Barriers and constraints
	discrepancies between crop statistics and National Land Cover (NLC) data	complete a proper assessment of croplands so this project can be included in the GHGIP.
	Improve Harvested Wood Products (HWP) model by incorporating further country specific data and by comparing the production method to the atmospheric model	Proposed project that could be considered under the GHGIP.
	Complete a full uncertainty analysis for the Land sector, including area bias corrections	Proposed to conduct a study to complete an uncertainty analysis for the Land sector, include all spatial data. This could be a project for the NGHGIP.
Waste	Improve Methane Correction Factor (MCF) and rate constants	This would require a study and will be recommended as a project under the GHGIP.
	Include economic data for different population groups	Study was completed in March 2020 so data will be included in next Inventory.
	Include information on population distribution in rural and urban areas as a function of income	Study was completed in March 2020 and data will be included in next inventory.
	Include HWP in solid waste	. Data may be insufficient, in which case further data collection will be suggested
	Obtain data on waste streams and the bucket system	Study was completed in March 2020 and data will be included in next inventory.
	CH_4, N_2O emissions from biological treatment of waste	Study was completed in March 2020 and data will be included in next inventory.
	CO_2, CH_4 and N_2O from waste incineration	Study was completed in March 2020 and data will be included in next inventory.

4.5.2 Capacity Building Needs for Adapting to Climate Change

There is a huge gap in South Africa for building capacity to address adaptation to climate change. The NCCAS (2020) has come up with nine strategic interventions to address adaptation in South Africa, with a vision to transition to a climate-resilient South Africa, which will follow a sustainable development path. This will be guided by anticipation, adaptation and recovery from a changing climate and environment to achieve our development aspirations. The nine strategic interventions are:

- Intervention 1: Reduce human, economic, environmental, physical and ecological infrastructure vulnerability and build adaptive capacity.
- Intervention 2: Develop a coordinated Climate Services system that provides climate products and services for key climate vulnerable sectors and geographic areas.
- Intervention 3: Develop a vulnerability and resilience methodology framework that integrates biophysical and socio-economic aspects of vulnerability and resilience.
- Intervention 4: Facilitate mainstreaming of adaptation responses into sectoral planning and implementation.
- Intervention 5: Promote research application, technology development, transfer and adoption to support planning and implementation.
- Intervention 6: Build the necessary capacity and awareness for climate change responses.
- Intervention 7: Establish effective governance and legislative processes to integrate climate change in development planning.

- Intervention 8: Enable substantial flows of climate change adaptation finance from various sources.
- Intervention 9: Develop and implement an M&E system that tracks implementation of adaptation actions and their effectiveness.

Furthermore, the Initiative for Climate Action Transparency (ICAT) country needs assessment report for South Africa study (CSIR, 2019), also identified one common capacity building need for adapting to climate change for South African Departments and its Entities. The recognised need is that of M&E of climate change adaptation activities within relevant institutions. Each of the needs specific to the government departments is provided in the table below.

Table 4-20: Capacity building needs identified in South African government departments

Institution	Identified need for Adaptation
Department of Water and Sanitation (DWS)	Relatively poor-quality quantitative M&E indicators are used for climate change and the organisational structure is not conducive to supporting an efficient M&E system in this regard.
Department of Science and Technology (DST)	A limited number of staff have climate change expertise nor the monitoring or evaluating skills of climate change. Furthermore, the department operates in a highly constrained financial environment which hampers adaptation efforts.
Department of Environmental Affairs (DEA) (now the Department of Forestry Fisheries and the Environment (DFFE))	Climate change adaptation M&E is not mainstreamed within the department's strategic planning or procedures i.e., effective leadership, record keeping, reviewing and monitoring compliance and risk management.
	Capacity building is required for climate change adaptation M&E for DFFE with particular focus on improving existing M&E systems, collection of data, inter-functional co-ordination and strategic communications. Further, they are lacking some partnership with academic institutions to address adaptation.
Department of Cooperative Governance and Traditional Affairs (COGTA)	The National Disaster Management Centre (NDMC), a department of COGTA, is designated with the responsibility of climate change adaptation M&E, however, capacity for M&E in disaster risk reduction or climate change is weak, as indicated by the poor quality of M&E reporting in performance plans. • The systems and infrastructure of the organisation are adequate to support the mandate of the organisation as defined by the Disaster Management Act No 57 of 2002, but there is no process indicated for organisational growth through continuous learning. • The leadership and staff engaged in projects directly or indirectly related to climate change adaptation do not have the required knowledge and understanding of climate change issues to effect climate change adaptation M&E in the organisation.
Department of Rural Development and Land Reform (DRDLR)	Climate change issues are not adequately addressed in the mission statement of the organisation and do not seem to feature strongly as part of their vision and goals.
Department of Health (DOH)	The DOH has weak capacity in systems and infrastructure to accomplish climate change adaptation M&E. Current systems in place for performance M&E are inadequate to support continuous learning and growth.
The Department of Human Settlement (DHS)	The Department does not have customised sector indicators to ensure consistency between performance targets and indicators reported on at the national and provincial levels.

Institution	Identified need for Adaptation
South African National Biodiversity Institute (SANBI)	There is less focus on climate change issues and there is no clear picture of how climate change is currently addressed within the organisation.
South African Environmental Observation Network (SAEON)	The organisation requires some capacity building to mainstream climate change adaptation M&E effectively into the organisation's goals and strategy. This could be done by including a separate climate change objective and incorporating of climate change adaptation M&E indicators into the annual report.
ESKOM	ESKOM does have the capacity in place to support climate change adaptation M&E as compared to with their success on tracking of mitigation actions and greenhouse gas emissions.
Research Alliance for Disaster and Risk Reduction (RADAR) and South African Local Government Association (SALGA)	Capacity building on climate change issues is needed in general and includes M&E of climate change related activities.

Lastly, the updated 2021 NDC's emphasis is on enhancing South Africa's mitigation efforts. While some investments are already underway domestically and will continue, it is acknowledged that international support will be necessary to achieve these goals. This highlights that efforts to address climate change adaptation are given little to no attention in the country.

4.5.3 Capacity Building Needs and Gaps for Climate Change Mitigation

Several gaps for climate change mitigation challenges were identified, with the 4th Biennial Update Report (2021) for South Africa highlighting the two most crucial capacity building needs as:

1. Building capacity around tracking of mitigation policies and measures and the assessment of mitigation policies and measures. Done through training courses (basic and complex).
2. Enhancing the capacity to track mitigation actions and PAMs in all sectors, particularly the AFOLU sector.

In addition to these capacity building needs, mitigation needs were identified around concessional finance for low carbon projects, debt restructuring, support by the international climate, a development and finance community for non-fossil-fuel development in Mpumalanga and elsewhere and infrastructure to support energy efficiency, transmission and green hydrogen in support of electric vehicles and public transport (DFFE, 2021b). Further, support will also be required for longer term decarbonisation which will require investments in the 2020s in infrastructure, technology development and capacity-building.

Table 4-21 provides technical and capacity building constraints for both adaptation and mitigation.

Table 4-21: Climate change adaptation and mitigation capacity building and technical needs

Constraint type	Description
Capacity building	Support the development of more integrative and systematic approaches to studying climate change which link the land, air and ocean components of climate change.
	Enhance capacity to identify and assess co-benefits and wider impacts of actions.
Technical and capacity building	Support technological innovation around social-ecological systems and sustainability. Large scale interdisciplinary,

	multi-site and multiscale programmes are needed to address integrative research needs.

4.5.4 Capacity Building Needs and Gaps - Research and Systematic Observations

Research and systematic observation capacity building needs and gaps were identified in the ICAT country Needs Assessment Report for South Africa Study (2019), which mentioned that there is a need to refine existing measures for M&E in disaster risk reduction (DAO G3) as the focus area of the Initiative for Climate Action Transparency for Adaptation (ICAT-A) project for South Africa and to include more details in terms of defining indicators used and assessing what can be improved to inform the research and systematic observations capacity building needs and gaps (CSIR, 2019). Research on how to involve the private sector/insurance schemes in this effort is also needed to identify pathways to supplement governmental resources for risk preparedness and responses. This includes capacity building needs and gaps for improving climate change education, training, social learning and public awareness. Specific training needs identified included training on early warning systems and training on developing and measuring/computing indicators relevant to climate change disaster risk reduction. Training on M&E tools and available systems and assistance to develop the M&E framework, Disaster Risk Reduction (DRR) and climate change into the organisation's strategy/plans and the envisaged Disaster Management Plan. Furthermore, the consideration of local languages when providing these training events, including that of the use of M&E-related tools, is key to ensure a use of language that is not too technical and that includes definitions of terminologies.

A gap for the SAEON relates to improving the communication of gender and social factors within the organisation and within projects by identifying appropriate M&E indicators for adaptation. M&E for climate change adaptation within the organisation could be affected by strengthening organisational structures and inclusion of staff into national capacity building workshops for climate change adaptation M&E.

4.5.5 Capacity Building Needs and Gaps for Technology Transfer

It is necessary to develop a better understanding of what tools can support refining the indicators and assessing what are the associated capacity building needs (CSIR, 2019). There is a need to identify gaps in the monitoring and observation network and addressing these gaps to ensure that national climate data is reliable, comparable, up to date and accessible. Early warning systems, with an initial focus on coastal regions, aims to enhance efficiency in monitoring and tracking effectiveness of adaptation actions in South Africa towards supporting the country's NFCS and the Desired Adaptation Outcomes. Specifically, the objective is to include more detail in terms of defining the indicators used and assessing what can be improved (CSIR, 2019).

4.5.6 Capacity Building Needs for Provincial to Local Government and State Entities

As the South African government is divided into 3 spheres: National, Provincial and Local, this section aims to provide capacity building needs for the provincial and local government. The challenges identified are outlined below.

Firstly, there is a need to improve the coordination of early warning systems in the different spheres of government, from national down to local (CSIR, 2019). This can be facilitated through developing a climate change early warning and vulnerability network to create a common understanding of the status of early warning systems; share information and promote collaboration among role players such as government and research institutions, technology start-ups, community organisations and neighbouring states. Disaster Management Services at the provincial level could investigate whether officers at the district municipality and service centre levels can understand and interpret Seasonal Forecast texts and maps. District municipality forums can be created for agricultural extension officers to collectively discuss the latest Seasonal Forecasts. Secondly, clear governance structures within government are needed, to differentiate the roles that provincial divisions have in making seasonal

forecast informed recommendations about crop and animal management; who has responsibility for disseminating the recommendations to district municipality and service centre levels; and through which channels this should be facilitated in order to improve communication platforms and increase dialogue between agriculture and disaster management stakeholders. DFFE has good platforms to disseminate climate change information but are mostly limited to the Western Cape. Other provinces are lacking information on climate impacts and dedicated adaptation strategies.

While the Department of Cooperative Governance's National Disaster Management Centre (NDMC) is a functional unit, disaster management systems at provincial and municipal levels are sometimes weak (CSIR, 2019). The NDMC faces various challenges, from provincial to municipal level for the implementation of monitoring and reporting procedures associated with disaster grants, including:

- Submission of incomplete documentation.
- Lack of proper reporting as per the frameworks.
- Inconsistencies with what was on the ground compared to what was reported.
- Infrastructure backlogs being included in the list of damaged infrastructure as a result of disasters.
- Projects falling within normal sector programs, appearing on disaster listed projects, such as drought projects.
- Insufficient capacity within the disaster management centres within the three spheres of government.

Lastly, SALGA as representatives of local government have recognised the need to generally improve technical skills in the sector and has identified partnerships with professional bodies as a means to achieve this. This is particularly the case for municipalities outside of the large metros. The need for skills development includes knowledge dissemination on climate change.

4.6 Information and networking

4.6.1 Local and Regional Information Networks

4.6.1.1 Climate Change Monitoring and Evaluation

The South African National Climate Change Information System (NCCIS), also referred to as the National Monitoring and Evaluation (M&E) system, is a web-based platform for the tracking, analysis and enhancement of South Africa's progress towards the country's transition to a low-carbon economy and climate-resilient society, as put forward in the National Climate Change Policy (DFFE, 2021). The platform collates climate related data and information from a range of sources (Figure 4-3) for the purposes of providing insights into the country's progress in responding to climate change and achieving national and international goals, including commitments and targets in terms of the NDC. The NCCIS offers a series of decision support tools to inform policy and decision-making, as well as showcasing information for South Africa's domestic and international reporting. It informs national decision makers, including Parliament and Cabinet as well as presenting South Africa's position in various negotiating platforms, such as the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC).

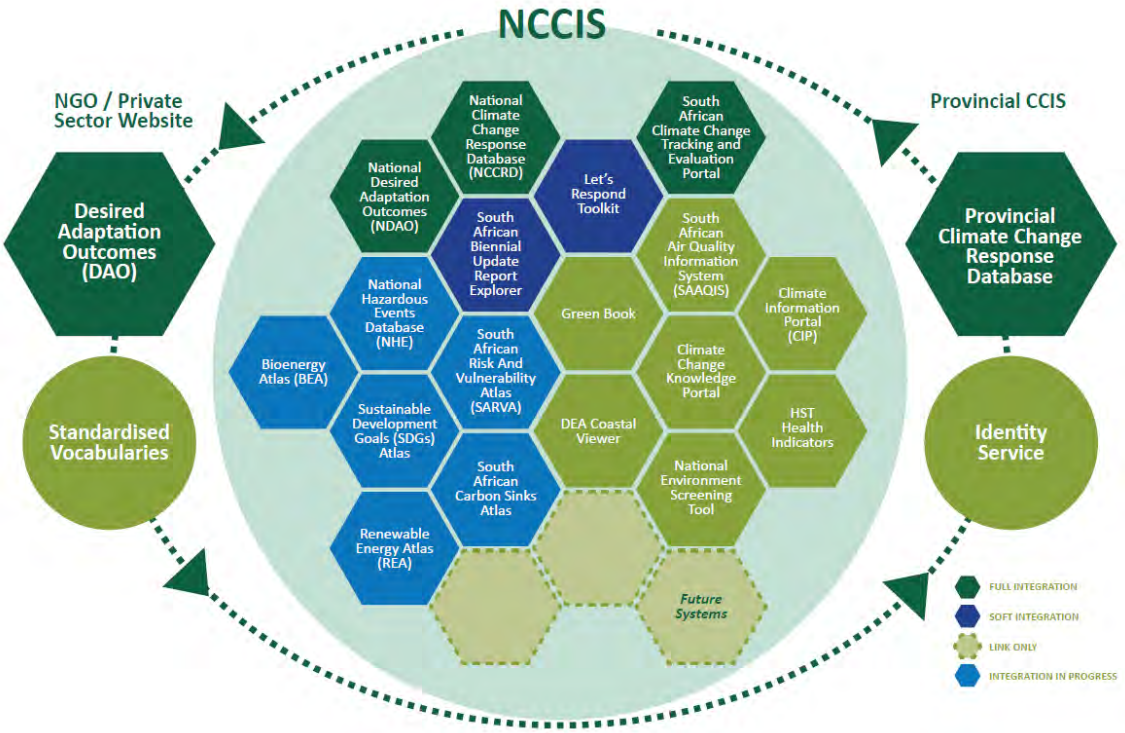

Figure 4-3: A Diagram of The South African National Climate Change Information System (NCCIS) and its Various Expandable Components

The NCCIS is supported by national, provincial and local scale systems of data-collection to provide complete, accurate and up to date data on:

- Greenhouse gas (GHG) emission reductions achieved through projects, policies and other related instruments/measures.
- Observed and projected climate change.
- Current and future risks, impacts and vulnerabilities.
- Climate resilience response measures.
- Analysis of the impact of adaptation and mitigation measures.
- Information on climate change financial flows.
- Tracking of technology transfer activities related to climate change initiatives.
- Climate change related tracking indicators.

The NCCIS showcases vital climate actions to inform domestic and international reporting. The NCCIS collects data and information from data custodians that use internationally recognised methodologies to collect and analyse data/information and which includes quality assurance and control. One such example is the work that is led by the South African Weather Service (SAWS) on climate indices, which has adopted the methodology and guidelines from the World Meteorological Organisation. Future work for the NCCIS includes the creation of subnational and sector specific systems, building on the work that has already been done on the NCCIS.

The South African M&E system encompasses all three functional aspects of the measurement, reporting and verification (MRV) system. These include MRV of GHG emissions, MRV of mitigation actions and MRV of Support. South Africa has adopted the approach of developing a climate change M&E system which integrates the analysis of all aspects of climate change MRV at multiple scales and also incorporates a national system for the compilation of GHG inventories. This makes the NCCIS M&E system the national central depository and portal for climate change information in South Africa.

4.6.1.2 Ministerial Talanoa Dialogue

Following the UNFCCC COP 23 in Bonn, Germany, the late Minister Dr. Edna Molewa; responsible for climate change in South Africa hosted the Talanoa Dialogue in 2018. The event was aimed at all South Africans and it brought together over 160 people ranging from government departments, the business community, academia, civil society organisations and representatives from international development partner countries. It sought to discuss the national contribution to the international effort to accelerate action and raise ambition to address the pressing challenge of climate change. In particular, the dialogue firstly discussed the vision for South Africa's transition towards a low emissions and climate-resilient future, taking views across different domains, including climate science, economic and development perspectives, as well as broad inputs from the National System of Innovation. It addressed all pillars of climate action, particularly mitigation, adaptation and support, with the latter considering not only finance, but also technology development and transfer, as well as capacity building.

The following are the key outcomes from this Talanoa dialogue (DEA, 2018):

- **On Aspiration**: The country aspires to become an environmentally sustainable society, that will transition towards a lower-carbon economy and climate-resilient society.
- **On Sustainability**: South Africa will contribute to the reduction of poverty, unemployment and social inequities by 2030.
- **On Just Transition**: Development should include, amongst other, National Economic Development and Labour Council (NEDLAC) inputs in order to develop sector jobs as industries are shifting to new cleaner technologies and processes.
- **On Climate Change mainstreaming**: Integrate climate change into development planning across spheres and sectors of the economy.
- **On Adaptation**: Emphasis on the centrality of adaptation where South Africa aspires to become climate proof and climate-resilient, with an enhanced understanding of its vulnerability and where climate change is fully integrated into development planning.
- **On Mitigation**: Importance of South Africa transitioning to a low-carbon economy within the context of sustainable development.

Coordination, international support, capacity building, education, awareness and proper institutional arrangements were identified as critical factors for success in this journey (ibid).

4.6.2 Global Information Networks

4.6.2.1 Partnership on Transparency in the Paris Agreement

The International Partnership on Mitigation and MRV was founded in 2010 by the South African Government Department of Environmental Affairs (now the DFFE), together with South Korea's Greenhouse Gas Inventory and Research Centre and Germany's Federal Ministry for Environment, Nature Conservation and Nuclear Safety. The aim of the Partnership was to promote ambitious climate action through policy dialogue and practitioner-based exchanges. In 2015, the Paris Agreement introduced the enhanced transparency framework, where its task is to facilitate and catalyse the implementation of the NDCs in order to keep the increase in average global temperature well below 2°C above pre-industrial levels, to pursue efforts to limit temperature increase to 1.5°C and to raise the ambition of the NDCs over time.

In 2016, the Partnership was renamed to the "Partnership on Transparency in the Paris Agreement", which reflected the new challenges arising from the transparency rules, while continuing to provide support for practical exchanges between developing and industrialised countries and serving as a discussion forum for climate negotiation topics. Since the Partnership on Transparency in the Paris

Agreement is a semi-formal forum, the Partnership has gained international recognition as currently more than 100 countries participate in the Partnership's various activities. Following the entry into force of the Paris Agreement 2016, the Partnership focused on the Agreement's implementation and particularly on the rollout of the enhanced transparency framework.

The mission of the Partnership is to support international efforts to engage in practical exchanges and political dialogue on climate change transparency. The new enhanced transparency system is of particular importance in this context, as it helps build mutual trust, fosters partner countries' growing ambitions and ultimately aims to limit global temperature rise to well below 2°C and ideally to 1.5°C.

The approach developed by the country partners is to bring together climate experts from a variety of countries and the Partnership seeks to:

- Foster transparency, communication, networking and trust between countries.
- Build capacity and foster a mutual learning process within regions and among practitioners around the globe.
- Identify and disseminate best practices and lessons learned.

Partnership formats include:

- Partnership Meetings on the fringes of UN climate negotiations.
- Policy dialogue during Annual Partnership Retreats.
- Capacity building activities and peer-to-peer learning through technical workshops in five regional and language groups.
- Knowledge products and knowledge sharing, for example, through newsletters and our website.

4.7 Gender and Climate Change

4.7.1.1 Existing Policies and Strategies Relating to Gender and Climate Change

A strategy for gender mainstreaming in the environmental sector was published by DEA for 2016 to 2021, titled Strategy toward gender mainstreaming in the environment sector 2016 - 2021. According to DEA (2016) the strategy aims to achieve gender mainstreaming and specifies the role of the environmental sector in South Africa.

The following materials were developed by DEA from 2014, to support the sector in adhering to the numerous requirements to advance gender equality in the country:

- Sector Gender Framework.
- Sector Gender Literature Review.
- Sector Gender Diagnostic Report.

Stakeholder engagements were carried out as part of the methodology and approach of the development of the materials. The engagements aimed to assure participation from all affected and relevant parties in order to develop a strategy that covers all gender mainstreaming concerns in the sector. The implementation of the gender priorities defined in the Strategy will necessitate the cooperation of all spheres, therefore stakeholders from both the private and public sectors, including all government departments, were represented.

The South African Constitution, the Convention on the Elimination of Discrimination Against Women (CEDAW), the National Policy Framework for Women's Empowerment and Gender Equality (2000), the Beijing Declaration and Platform for Action, the Convention on the Elimination of Discrimination Against Women, the National Environmental Management Act, the South African Development

Community (SADC) Protocol on Gender and Development and the Gender Plan of Action under the Convention on Biological Diversity, were among the legislative and policy contexts that were examined to develop the strategy. Furthermore, the following international treaties, to which South Africa is committed, demonstrate the country's participation and dedication to the advancement of gender equality:

- Beijing Declaration and Platform 171or Action (1995).
- United Nations Women Strategic Plan (2014 – 2017).
- The Convention for Biological Diversity Gender Action Plan (2008).
- The Convention on Biological Diversity (CBD).
- The United Nations Convention to Combat Desertification (UNCCD).
- The United Nations Framework Convention on Climate Change (UNFCCC).

Several country reports in response to gender mainstreaming in the country is further showcased in conventions and platforms, such as the South Africa Beijing +20 Report (2015), I Status of Women in the South African Economy (2015), Towards an Enabling Environment for Women Economic Empowerment in South Africa - A Status Quo Report (2011) and Millennium Development Goals Country Reports. In addition, the Expanded Public Works Programme (EPWP) incorporates the following programmes:

- Working for Water (WfW) - In the interest of environmental sustainability, the WfW views human development as a crucial component and it aims to recruit 60% women, 20% youth and 5% disabled persons. The initiative has helped almost 20 000 people, 52% of whom are women, gain employment and receive training.
- Working for Land (WfL) - The aim of this Public Works Program includes 60% women, 20% youth and 2% people with disabilities.
- Working for Wetlands - The programme is implemented by the South African National Biodiversity Institute (SANBI) on behalf of the DFFE and the Department of Water Affairs (DWA).
- Working on Fire (WoF) – WoF employs more than 5 000 young men and women, who have been fully trained as wildfire firefighters and are stationed in more than 200 bases throughout South Africa (Working On Fire, 2023). With the application of Integrated Fire Management (IFM) principles, WoF targets the prevention and control of wildfires to improve sustainability and protection of life, poverty and the environment. The programme includes 37% women and 85% young people (the highest level in any comparable fire service in the world).

The Strategy toward gender mainstreaming in the environment sector 2016 – 2021 also covers the inclusion of gender perspectives in environmental programmes with an emphasis on the primary concerns and entry points for gender mainstreaming, within the specified fields. The identified fields are gender and environmental sciences, gender and green economy, gender and climate change, gender and waste management, gender and biodiversity / conservation / oceans / coasts management and gender and air quality management.

The strategy has identified twelve key strategies that are designed to provide guidance, create an enabling environment and be non-prescriptive. The roll-out of the strategy is a key component and will provide relevant support for other sector partners in further development and alignment of gender mainstreaming.

The key strategies are:

- **Strategy 1: Policy Formulation**
  To support policy formulation in order to strengthen the policy positions on gender in the Environmental Services Sector.

- **Strategy 2: Institutional Support**
  To ensure that institutional arrangements support human resource development and mainstreaming of gender at all levels of government.

- **Strategy 3: Programme Management**
  To develop a programme management approach that mainstreams gender into all parts of the project cycle.

- **Strategy 4: Resource Mobilisation**
  To ensure that adequate financial resources are allocated to gender mainstreaming through strategic resource mobilisation.

- **Strategy 5: Communication Management**
  To develop an effective communication management system through sharing of information and promoting gender equality.

- **Strategy 6: Internal Transformation**
  To ensure that the internal transformation processes of institutions and structures support equal representation and participation of women.

- **Strategy 7: Economic Transformation**
  To support women's empowerment and gender equality through economic transformation and control of resources.

- **Strategy 8: Partnerships and Networking**
  To strengthen partnerships and networking between the stakeholder community to support an integrated gender mainstreaming approach.

- **Strategy 9: Monitoring, Evaluation and Reporting**
  To develop a monitoring and evaluation system with the associated instruments and indicators that support gender equality.

- **Strategy 10: Capacity Building**
  To develop capacity building programmes that are aligned with skills development and which support women's empowerment and gender equality interventions.

- **Strategy 11: Advocacy and Awareness Raising**
  To support advocacy and awareness raising programmes that will encourage gender transformation at every level of society. This strategy should be developed from the grassroots level as opposed to a top-down approach. Provinces will be pivotal in running and ensuring the success of such programmes.

- **Strategy 12: Research and Evidence**
  To conduct research and develop evidence that is reflective, uses appropriate instruments, utilises good practice and leads to future gender planning.

Lastly, the strategy provides roles and responsibilities for the different spheres of government, as presented in Table 4-22.

Table 4-22: Gender mainstreaming strategy's roles and responsibilities for the National, Pro incial and Local governments

National Government	Provincial Government	Local Government
▪ **Develop relevant policies / strategies to address gender mainstreaming in the sector.** ▪ **Capacity building provinces and municipalities regarding their role in mainstreaming gender in the sector.** ▪ **Coordinating implementation of the strategy (forums / committees).** ▪ **Monitoring and Reporting.** ▪ **Research and evidence.** ▪ **Advocacy and institutionalisation.** ▪ **Establish strategic partnerships to advance the goals of the strategy.** ▪ **As far as possible explore funding opportunities and models for the implementation of the Strategy.**	▪ Responsible to create a conducive environment for policy and strategy implementation. ▪ Responsible to establish mechanisms for implementation e.g., enablers. ▪ Identify beneficiaries and coordinate the establishment and running of provincial forums. It is very important that provinces are also involved in coordinating implementation in their provinces to avoid duplication and confusing target audiences. ▪ Responsible to co-ordinate all interventions to address gender mainstreaming. ▪ Consolidation data to highlight successes gabs and lessons learnt.	▪ Establish implementation and reporting mechanisms for the strategy. ▪ Drive implementation of the strategy (forums / committees / councils). ▪ Facilitate buy-in of strategy with political leadership within municipalities. ▪ Establish partnerships for implementation (e.g., funding opportunities). ▪ Develop reports on implementation (aligned to the financial year).

The following guiding principles for the implementation of the NCCAS considers gender mainstreaming (DEFF, 2020):

- Gender-responsive entails that the development and implementation of the NCCAS will promote the participation of women, it will take gender differences to climate change vulnerability into account, it will address the needs and priorities of both women and men and it will not exacerbate gender inequalities.
- Consideration of vulnerable groups: The development and implementation of the NCCAS will promote the participation of vulnerable groups and build resilience and adaptive capacity of the most vulnerable people, such as women, especially poor and/or rural women; children, especially infants and child headed families, the aged, the sick and the physically challenged.

This highlights the commitment of the South African government to mainstreaming gender equality as the key principle and pillar of success for the full implementation of the NCCAS.

4.7.1.2 Gender Mainstreaming in the National and Subnational Climate Change Response Strategies and Development Plans

The South African government is working on adopting the gender-responsive climate change policies and strategies to ensure that women's needs are considered in the design and implementation of climate change strategies. The National Climate Change Response White Paper (2011) explicitly acknowledges the need to address gender inequality to effectively address climate change. It states that *"*climate change impacts are not gender-neutral and the way in which decision-making is structured can aggravate existing gender inequalities*"* (DEA, 2011).

To address gender inequalities in South Africa's climate change response, two workshops were hosted by the DFFE. The first workshop, entitled "**Gender Differentiation workshop under the**

Capacity Building Initiati e for Transparency CBIT project of South Africa", was hosted in 2020. The workshop had participants ranging from government representatives from the Academy of Science of South Africa (ASSAf), the Western Cape Government, South African Weather Services (SAWS), South African National Parks (SANParks), Gauteng Government, Limpopo Economic Development, Environment and Tourism (Ledet) and GenderCC South Africa.
The main objectives of this workshop were to:

- Introduce the Capacity Building Initiative for Transparency (CBIT) project towards gender and climate change.
- Share knowledge and experience on gender and climate change within the South African context.
- Highlight the gaps in the National Climate Change policies and encourage gender mainstreaming in the development, implementation and reporting of climate change.
- Enhance the capacity of South Africa's decision makers, policy developers and stakeholders to develop gender-responsive policies, plans and programmes on climate change.

The workshop represented the South African Government's efforts to ensure that all women are recognised and gender equality is recognised as an important aspect in fighting climate change.

The following describes the key highlights of the workshop:

- Gender consideration under the Paris Agreement was introduced in the country and gender equity was acknowledged as a necessity to address climate change for adaptation and capacity building.
- The CBIT project was introduced, which serves to help strengthen the institutional and technical capacities of developing countries to meet the enhanced transparency requirements as defined in Article 13 of the Paris Agreement.
- The Global Environment Fund (GEF) funding support was announced and funding were received to support the South African government to prepare itself for the Enhanced Transparency Framework. The fund also allocated a budget for conducting Gender and Climate workshops.
- A Gender into Urban Climate Change Initiatives project was presented. The project focused on building capacity for women's organisations and community groups on climate change, undertaking a gender analysis of climate policies in national departments, exploring options for integrating gender and social aspects into national climate change responses, building the capacity of national departments on gender and climate change and developing recommendations for gender-responsive national climate policies.
    - The findings of the Gender into Urban Climate Change Initiative project climate change national baseline report, in relation to the gender report, found that each sector has unique issues needing to be addressed, as well as unique gender implications. The report also revealed that the majority of South Africans living in abject poverty are women living in peri-urban and rural areas in both formal and informal settlements, resulting in women being the hardest hit by the impacts of climate change i.e., food security and destruction of houses due to extreme weather. Further, it was found that there is limited knowledge and capacity on gender dimensions of climate change in cities, but only a few cities have made efforts to mainstream gender since the project's intervention.
    - The project's recommendations for addressing the challenges mentioned above involved promoting/raising education and awareness and sensitising gender and climate change, improving collaboration of gender and climate change experts i.e., from the city and civil society, collecting disaggregated sex and gender data, determining an approachable language in raising awareness and communicating

climate change messages and lastly, promoting pro-poor policies which provide unlimited access for women to mobility, electricity water and sanitation.

- The UN Women – South Africa Multi Country Office (SAMCO) was present and its role has alluded to support inter-governmental bodies, such as the Commission on the Status of Women in formulating policies, global standards and norms. The UN Women does this by providing suitable technical and financial support, forging partnerships with civil society and ensuring that the UN system is held accountable for its own commitment on gender equality, including regular monitoring of system-wide progress. The UN Women aims to improve economic empowerment goals for women through Climate Smart Agriculture (CSA), by:
  - Touching and changing lives of at least 10 000 women.
  - Increasing women farmers productivity and access to land.
  - Training and skills development for women on Climate Change and CSA technology.
  - Opportunities and platforms for organised women to grow in all aspects of life.
  - Women's participation in the whole value chain.
  - Increasing access to markets and decision making.
  - Providing tailored finance for women.
  - Training and encouraging use of ICT PLATFORMS (4th Industrial Revolution).

- The Academy of Science of South Africa provided the last presentation which focussed on applying a gender lens to science, technology and innovation. It was highlighted that more women are needed in research and in decision-making bodies. Gender in Science, Innovation, Technology and Engineering (SITE) an international initiative to promote the role of gender in the industry was also introduced, which aims to demonstrate how applying a gender lens to SITE can provide deeper insight, more effective programmes and more sustainable outcomes in the context of development.

The concluding remarks for the workshop were to host a physical workshop on gender in 2021, consisting of provincial stakeholders. Furthermore, the gender and climate change knowledge should be communicated to rural communities; collaboration is encouraged as the Limpopo provincial government considered to collaborate for the physical workshop as the CBIT funds were not enough and that gender/women issues should not be considered only in August of every year (national women's month), but throughout the year.

This first workshop resulted in the second workshop taking place, which was hosted in 2021 under the title: **Second Gender Mainstreaming workshop under the CBIT project of South Africa**. Still hosted by DFFE, this workshop was organised as a hybrid workshop, including in-person and online participants due to Covid-19 regulations. Participation in this workshop was wide and included representatives from the Western Cape government, South African Weather Services (SAWS), South African National Parks (SANParks), Gauteng government, Limpopo Economic Development, Environment and Tourism (Ledet), Gender CC South Africa, United Nations Industrial Development Organisation (UNIDO) and National Business Initiative (NBI). The objectives for this workshop were to:

- Share knowledge and experience on gender and climate change within the South African context.
- Highlight the gaps in the National Climate Change policies and encourage gender mainstreaming in the development, implementation and reporting of climate change.
- Enhance the capacity of South Africa's decision makers, policy developers and stakeholders to develop gender-responsive policies, plans and programmes on climate change.

The workshop was as a result of a partner with the DFFE's Climate Change Development and International Mechanisms (CCDIM) Directorate in order to work towards achieving one plan of gender

mainstreaming and to also build capacity and skills development needs. The workshop was funded by the GEF as part of the CBIT project of South Africa.

Four speakers were invited and the following key points were highlighted:

- The first presentation was on gender mainstreaming climate change policies. The presentation focused on:
    - Providing context that gender mainstreaming in climate change should be a strategy for making gender concerns and experiences an integral dimension of the design, implementation, monitoring and evaluation of policies and programmes in all political, economic and societal spheres. In doing so, men and women benefit equally and inequality is not perpetuated.
    - Reporting on findings and recommendations for Economic Empowerment of Women in Green Industry (EEWIGI) Policy assessment. EEWIGI is crucial in South Africa as it initiates a significant push to improve leadership and participation of women as entrepreneurs and industry professionals and advances gender equality, as well as gender industrialisation in line with the SDGs.
    - It was found that about 50% of South African Green Policies are not gender mainstreamed, highlighting the need for more structured and intentional support to enhance women's empowerment.
- A presentation on Climate Change Gender Mainstreaming from the National Business Institute (NBI) was provided. The NBI was introduced as an institute which works with its members to enhance their capacity for change, to leverage the power of their collective, to build trust in the role of business in society, to enable action by business to transform society and to create investment opportunities.
    - The NBI recognises that inequality in South Africa disproportionally affects women in different dimensions i.e., economically (per capita income and expenditure), asset and wealth (household asset ownership), labour market (access to employment, participation, income), socially (access to education, healthcare and basic services), social mobility (free movement between social strata and classes).
    - In 2021, South Africa had a Gini score of 63 where women were found to be the most vulnerable to poverty and that they constitute most of the population living with poverty. The share of women's household income and expenditure is significantly lower than that of men. Furthermore, South Africa's labour market was found to be heavily racialised and gender biased, with more men than women participating in the labour market.
    - In the second quarter of 2021, it was found that black African women had an unemployment rate of 41%, female workers earned about 30% less, on average, than male workers across all educational levels, women are more likely than men to be doing unpaid work and are often excluded in decision-making and women, especially black and coloured women, are under-represented in high-skilled and management positions.
- As was in the first workshop, Gender CC was also present, providing a presentation on - Gender into Urban Climate Change Initiatives project to a wider audience. The project focused on the following: building capacity for women's organisations and community groups on climate change, undertaking a gender analysis of climate policies in national departments, exploring options for integrating gender and social aspects into national climate change responses, building capacity of national departments on gender and climate change and developing recommendations for gender-responsive national climate policies.
- Lastly, the Western Cape Government presented on the Department of Public Service and Administration (DPSA) gender mainstreaming training. The presentation mentioned that a

special effort should be made to engage women's groups on their challenges as part of policy engagement processes and engage networks and relevant stakeholders on determining who is already collecting applicable gender disaggregated data. Furthermore, it was mentioned that gender mainstreaming should be discussed often i.e., to create awareness of different impacts on gender and encourage service providers to include the vulnerable groups (women, the youth and the disabled) in project teams to ensure capacity building and skills transfer within the environmental sector. Gender mainstreaming into strategy related project planning across different departments is crucial, as it reduces the entrenchment of gender inequality.

Furthermore, the South African government is also working on the draft Climate Change Gender Action Plan which will be finalised and published in June 2024. The goal of the Gender Action Plan is to consider the current state of gender mainstreaming in South Africa against the desired future state, as outlined in the latest NDC of South Africa, as well as its future iterations. The further goal is to ensure that South African climate change policies are increasingly gender-responsive and enabled by gender-climate mainstreaming that enables positive and tangible progress in national climate change responses, because women and girls are at the forefront of vulnerability.

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5 Constraints, Gaps and Related Financial, Technical and Capacity Needs

An analysis of perceptions of climate governance by South Africa's leading experts, from national and subnational government and sectoral agencies, the private sector, civil society and academia, has revealed that there are at least four general challenges that hinder efficient climate governance in South Africa (Averchenkova, Gannon and Curran, 2019). Firstly, overstressed technical and human capacity i.e., a lack of necessary knowledge and skills along with a lack of adequate financial and human resources. Secondly, historical conflicts between the main stakeholders, for example, between and within government agencies, state-owned enterprises, academic research institutions, civil society and labour unions.

These conflicts are suspected to be brought on by mistrust, strained ties with the past and concerns about the speed, scope and nature of policymaking. Thirdly, a lack of ownership on implementation agendas, unclear responsibility assignments, multiple ministries tackling similar problems parallel with little coordination and time-consuming and inefficient communication techniques. Lastly, there is a lack of funding for the low-carbon and climate-resilient transition, policy implementation and the underlying investments that are necessary to strengthen governance capacities to work on climate change in the key agencies.

In this chapter, information on constraints and gaps related to financial, technical and capacity needs is provided. This includes the support needed and received to enable the preparation and submission of South Africa's fourth national communication report. On capacity building, this chapter only includes those additional needs and constraints that have not yet been included in the dedicated capacity building section in Chapter 5.

5.1 Previously Identified Needs, Constraints and Gaps

This section aims to provide a status update of the constrains, gaps and needs identified in previous national communications and biennial update reports, progress towards addressing those needs, as well as any outstanding needs for GHG inventory compilation, mitigation and adaptation to climate change. These are summarised in the table below:

Table 5-1: Status of previously identified needs, constraints and gaps

Focus	Type	Previously identified constraints and needs	Progress towards addressing the need	Outstanding needs
GHG Inventory	Capacity building	Enhancing technical capacity for GHG inventory development on a regular and continuous basis. Specifically, to develop training courses covering the GHG inventory update process (IPCC guideline methodologies for sectors, quality assurance/ quality control (QA/QC) process and methods, uncertainty analysis, key category analysis, coordination and management of update process).	A service-provider conducted training for the DFFE inventory team on the NGHGIS, inventory process, inventory updating, QA/QC process, key category analysis and uncertainty (with all presentations and training material being uploaded onto the NGHGIS), however, specific training courses have not been developed yet. Also, through CBIT funding, the DFFE has appointed Zutari, as a service-provider, to develop a long-term Strategy for capacity building on GHG inventory compilation and to implement it. The Strategy is to be completed by 31st of December 2023, while development of training manuals and delivery of the training programme are scheduled to be completed by 30th of April 2024.	No further capacity needed.
		Enhancing technical capacity for the development of the GHG management system, including for: i. Operationalising the system in terms of the personnel capacity to operate and maintain it. ii. Operationalising QA/QC components, processes and plans.	Additional inventory team staff were appointed at the DFFE to manage the NGHGIS and to compile the inventory. The GHG Inventory team is now responsible for full management of the National GHG management system. Training has been provided on overall functioning of the NGHGIS and there are currently plans underway to provide operational training on the system management for the NGHGIS. Once-off training on the QA/QC process has also been provided. Furthermore, a 10-year business case for the institutional set up of the South African GHG Emissions Reporting System (SAGERS) has been developed with the support of the World Resources Institute (WRI) and Zutari. It identified and assessed capacity, financial and information technology needs of SAGERS for it to adequately support GHG inventory compilation.	Operational training on the system is still required, but this is underway through WRI funding.

Focus	Type	Previously identified constraints and needs	Progress towards addressing the need	Outstanding needs
			Finally, the DFFE GHG inventory team has been holding peer-to-peer workshops with the GHG inventory team of the United States of America to share experiences and lessons learnt.	
	Technical	Enhancing capacity related to the use of surrogate data or other splicing techniques from the 2006 IPCC Guidelines that can help fill data gaps and generate a consistent time series (including a dedicated project to specifically address the technical capacity and additional personnel needed to ensure that inventories are recalculated in cases where historical data or inventory years are missing).	The inventory team is currently working on extending the time-series back to 1990 for the inventory and filling in data where it is missing. The full time-series has been completed for the AFOLU sector, while for other sectors, this should be completed by the 1st BTR.	No further technical capacity is needed.
		Support is needed to produce updated land use change maps in the AFOLU sector.	The DFFE Geographical Information System (GIS) unit has set up a process to develop land cover maps internally, without external support. The latest Land cover map has successfully been produced for 2018.	No further technical capacity is needed.
		Enhancing technical capacity for tracking land-use changes.	Not yet started.	Technical capacity is still required for this, but it is planned to be undertaken with funding by CBIT.
	Technical and Capacity Building	Support is needed for sector-specific priority data generation processes to improve the GHG inventory.	A GHG improvement programme was set up in 2011, which is on-going. A fuel consumption survey was done to improve activity data for the period 2000–2018. A model for road transportation has been created, where the results of this study have started to be	The National Greenhouse Gas Improvement Programme is on-going, in that additional projects are continually added. Therefore, technical and capacity support is required to

Focus	Type	Previously identified constraints and needs	Progress towards addressing the need	Outstanding needs
		Information on country specific emission factors in all sectors is required, with a particular need to improve data in the transport and waste sectors, as well as some key categories in the AFOLU sector (e.g., direct and indirect N_2O emissions from managed soils and land converted to cropland)	incorporated into the 2017 GHG Inventory, with all results being incorporated by the next inventory. Waste studies are still required, along with studies to develop country specific emission factors for direct and indirect N_2O from managed soils.	complete these focused activities. A tender has been published, with CBIT funding support, to support DFFE with generation of AFOLU activity data and emission factors.
		Enhancing technical capacity for data collection on a regular basis to improve the accuracy of the emission estimates for both waterborne navigation and marine bunkers, including improving the capacity to develop modelling tools and to estimate GHG emissions for the transport sector in general.	Fuel consumption study for road transport is in progress and should be completed.	Capacity is still required for regular data collection of waterborne navigation and marine bunkers.
Mitigation actions	Capacity Building	Build capacity around tracking of mitigation policies and measures and the assessment of mitigation policies and measures. Done through training courses (basic and complex).	Through CBIT funding, DFFE has appointed Zutari, as a service-provider, to develop a long-term Strategy for capacity building on mitigation impact assessment and to implement it. The Strategy is to be completed by 31st of December 2023, while development of training manuals and delivery of the training programme are scheduled to be completed by 30th of April 2024.	No further capacity needed.
		Enhancing the capacity of data providers to estimate emission reductions, track the progress of mitigation actions and share data on emission reductions	Two studies are underway by the Council for Scientific and Industrial Research (CSIR) on quantification of actions for the Waste and AFOLU sectors.	No further capacity is required.

Focus	Type	Previously identified constraints and needs	Progress towards addressing the need	Outstanding needs
		and progress on a regular and continuous basis.	The abovementioned project funded by CBIT and implemented by Zutari also addresses this need.	
	Technical	Enhancing the technical capacity of the DFFE to assess and track progress in the implementation of mitigation actions.	The national Monitoring & Evaluation (M&E) system has been set up to assist the DFFE in tracking mitigation actions. The system is fully operational, but training of the DFFE staff is currently in progress. Assistance is being provided by a service-provider to populate the system.	No further capacity is required.
Adaptation	Capacity Building	Support for the development of more integrative and systematic approaches to studying climate change which links the land, air and ocean components of climate change.	Update on progress not available yet	Capacity is still required to complete this activity.
		Enhancing competencies to support or conduct vulnerability assessments and climate risks analyses, particularly at local and provincial levels	Update on progress not available yet.	Capacity is still required to complete this activity.
		Building the capacity for undertaking comprehensive technical analyses to identify constraints and gaps at the operational level cropland.	Complete.	No further support is required for this activity.
	Technical and Capacity Building	Support for technological innovation around social-ecological systems and sustainability. Large scale interdisciplinary, multisite, multiscale programmes are needed to address integrative research needs.	Update on progress not available yet.	Support is still needed for integrative research.

Focus	Type	Previously identified constraints and needs	Progress towards addressing the need	Outstanding needs
	Financial	Access to and availability of financial resources dedicated to climate change adaptation planning (e.g., for the development of impact and/or vulnerability assessments) and for the implementation of specific adaptation actions	Update on progress not available yet.	Support is still needed for this
Cross-cutting	Technical	Integration of climate change considerations into municipal development planning tools, such as the IDPs and Spatial Development Plans (SDPs)	Update on progress not available yet.	Support is still needed for this.

5.2 Further Financial Constraints, Gaps and Needs

Significant and scaled-up resources are needed in South Africa for mitigation and adaptation actions across the entire economy. The South African government is putting in place an enabling institutional environment that can support a sustainable climate finance model, where mitigation and adaptation actions are funded over the long term and where this funding is accessible in a timeous manner to a broad range of stakeholders, but this will take time to complete. Table 5-2 to Table 5-12 presents the support needed by South Africa for mitigation and adaptation actions by sectors.

Table 5-2: Support needed for Agriculture, Forestry and Fisheries

Agriculture, Forestry and Fisheries						
Support needed for mitigation and adaptation actions by sector	Support Types Needed			Funding by Preferred Type		
	Mitigation	**Adaptation**	**Capacity Building**	**Technical Support**	**Technology Support**	**Grant**
Agriculture Sector Support and promote activities related to: - Conservation agriculture - Climate smart agriculture - Developing water infrastructure and conservation measures - Rangeland and livestock management Fisheries Sector Large scale: - Changing the target species according to changes in species mix, abundance and distribution. - Following the fish over large distances to maximise catch rates, which is made possible by the size, range and endurance of the vessels. - Improving catching, processing and distribution efficiency through the introduction of new technologies. - Rationalising existing facilities within and between the companies. - Countering lower catches by reducing wastage, improving the value of existing products via product beneficiation and introducing new and improved marketing strategies. - Stabilising and improving the skills of the labour force through the provision of support infrastructure and education and health facilities.		X	X	X	X	X

- Selling less economic, less efficient vessels and selling or moving surplus processing machinery to another area or fishery. - Importing fish when production is unable to meet the local demand, thus retaining market share, preserving local markets and retaining the capacity to increase local production should conditions improve. - Coping with the problems of increased bad weather and damage to infrastructure within the companies' existing risk management strategies. Forestry Sector Support and promote activities related to: - Strengthening community-based forestry and diversification of livelihood skills - Improving inter-departmental collaboration - Identifying key strategic areas of project implementation - Fire mitigation - Implementing disaster management and early warning systems - Integrating climate change into forestry curricula - Supporting ecosystems-based adaptation - Plan and implement multi-objective landscape level planning. - Establishing and maintaining quantified baselines							

Table 5-3: Support needed for the coastal zones sector

Coastal Zones Sector							
Support needed for mitigation and adaptation actions by sector		Support types needed			Funding by preferred type		
		Mitigation	**Adaptation**	**Capacity Building**	**Technical Support**	**Technology Support**	**Grant**
PRIORITY 1: Develop Norms and standards for modelling of sea-level rise projections. PRIORITY 2:	PRIORITY 7: Develop an ocean and coastal information management system with public access. PRIORITY 8:		X	X	X	X	X

Develop norms and standards for modelling of storm surge projections. PRIORITY 3: Develop guidelines for coastal defence (e.g., environmental engineering approaches). PRIORITY 4: Prepare a coastal hazard zone index and demarcate coastal hazard zones (including impacts from climate change). PRIORITY 5: Develop effluent emission limits or standards. PRIORITY 6: Develop a National Coastal Water Quality Monitoring and Assessment Programme.	Develop a National Strategy for awareness, education and training in the coastal sector. Develop a Strategy to strengthen coastal awareness in school curricula. PRIORITY 9: Develop a strategy for engaging coastal traditional councils in management. PRIORITY 10: Establish Memorandums of Understanding with other institutions to strengthen research and capacity building for coastal management in South Africa.						

Table 5-4: Support needed for the health sector

Health Sector							
	Support types needed			Funding by preferred type			
Support needed for mitigation and adaptation actions by sector	**Mitigation**	**Adaptation**	**Capacity Building**	**Technical Support**	**Technology Support**	**Grant**
The South African National Climate Change and Health Adaptation Plan is rooted in the key elements of a public health approach to climate change. The Plan's actions are categorised into short-, medium- and long-term actions: • Short-term actions: Review the National Climate Change and Health Steering Committee, capacity building interventions and participate in		X	X	X	X	X

international exchange and collaboration. • Medium-term actions: Review monitoring and surveillance systems, create intersectoral action health system readiness and indicator development. • Long-term actions: Conduct national vulnerability assessments, research and development on risks of climate change to health, conduct health impact assessments, model and pilot climate change and health adaptation projects and identify adaptation actions.						

Table 5-5: Support needed for the biodiversity sector

Biodiversity Sector						
Support needed for mitigation and adaptation actions by sector	Support types needed			Funding by preferred type		
	Mitigation	**Adaptation**	**Capacity Building**	**Technical Support**	**Technology Support**	**Grant**
• Evaluate the spatial planning approaches that change the mix of activities which take place in given biomes, including the possibility of abandoning some uses completely and introducing new ones. • Management approaches which adjust the way in which the land uses are executed under a changing climate, for instance by changing the species used, or the intensity of use. • Ecosystem-based adaptation, which sets out to support the inherent ability of ecosystems, including their human inhabitants and organisms, to adapt to climate change, principally by reducing other stresses which might impede that capacity and restoring ecosystem function where it has been damaged. • Biodiversity stewardship programmes, which, by expanding protected areas on private land and promoting sustainable land management through management agreements, can form corridors that will enhance the adaptive capacity outside of state-owned protected areas.		X	X	X	X	X

Table 5-6: Support needed for the urban and rural settlements sector

Urban And Rural Settlements Sector						
Support needed for mitigation and adaptation actions by sector	Support types needed			Funding by preferred type		
	Mitigation	**Adaptation**	**Capacity Building**	**Technical Support**	**Technology Support**	**Grant**
• Environmentally sustainable land use development. • Integrated Development Planning. • Needs and priorities of people in informal settlements. • Environmentally sound low-cost housing and planning for housing development.		X	X	X	X	X

Table 5-7: Support needed for the water resources sector

Water Resources Sector						
Support needed for mitigation and adaptation actions by sector	Support types needed			Funding by preferred type		
	Mitigation	**Adaptation**	**Capacity Building**	**Technical Support**	**Technology Support**	**Grant**
• Water governance – building adaptive institutions, creating intergovernmental relations, awareness, communication, research and development, stakeholder participation, regional development and the review of strategies. • Infrastructure development, operation and maintenance – multi-purpose water storage, water supply and sanitation, groundwater development and management, flood protection measures, infrastructure safety and hydro-geo-meteorological monitoring system. • Monitoring and management – Data and information gathering, scenarios and climate modelling, vulnerability assessments, planning, water allocation and authorisation, optimisation of dam and groundwater operation, water conservation and water demand management, water quality management, resource management and protection.		X	X	X	X	X

Table 5-8: Support needed for the energy sector: 1A1 energy industries

Actions in Energy Sector: 1A1 Energy Industries						
Support needed for mitigation and adaptation actions by sector	Support types needed			Funding by preferred type		
	Mitigation	**Adaptation**	**Capacity Building**	**Technical Support**	**Technology Support**	**Grant**
• 12L tax incentive programme. • Appliance Labelling project. • Eskom Integrated Demand Management (IDM) programme. • Municipal Energy Efficiency and Demand-side Management programme. • The National Cleaner Production Centre (NCPC) programme.	X		X	X	X	X

Table 5-9: Support needed for the Energy sector: A2 manufacturing industries and construction

Actions in Energy Sector: A2 Manufacturing Industries and Construction						
Support needed for mitigation and adaptation actions by sector	Support types needed			Funding by preferred type		
	Mitigation	**Adaptation**	**Capacity Building**	**Technical Support**	**Technology Support**	**Grant**
• Natural gas fuel switch programme	X		X	X	X	X

Table 5-10: Support needed for the energy sector: 1A3 transport

Actions in Energy Sector: 1A3 Transport						
Support needed for mitigation and adaptation actions by sector	Support types needed			Funding by preferred type		
	Mitigation	**Adaptation**	**Capacity Building**	**Technical Support**	**Technology Support**	**Grant**
• Bus Rapid Transport System. • Electric vehicles. • Transnet Road-to-Rail programme.	X		X	X	X	X

Table 5-11: Support needed for the IPPU sector

Actions in IPPU Sector						
Support needed for mitigation and adaptation actions by sector	Support types needed			Funding by preferred type		
	Mitigation	**Adaptation**	**Capacity Building**	**Technical Support**	**Technology Support**	**Grant**
• Nitrous oxide emission reductions. • Carbon budgets and pollution prevention plans (only process emissions).	X		X	X	X	X

Table 5-12: Support needed for the waste sector

Actions in Waste Sector						
Support needed for mitigation and adaptation actions by sector	Support types needed			Funding by preferred type		
	Mitigation	**Adaptation**	**Capacity Building**	**Technical Support**	**Technology Support**	**Grant**
• Waste Management Flagship programme: • The Climate Change Response Public Works Flagship Programme. • The Water Conservation Flagship Programme. • The Renewable Energy Flagship Programme. • The Energy Efficiency & Management Flagship Programme. • The Transport Flagship Programme. • The Waste Management Flagship Programme. • The Carbon Capture & Sequestration Flagship Programme. • Long-term Adaptation Scenarios Flagship Research Programme.	X		X	X	X	X

5.3 Further Technology Constraints, Needs and Gaps

The Technological Needs Assessment study was conducted to determine key sectors' mitigation and adaptation needs as part of the country's climate change response measures and development goals. The objective of the study was to provide a basis from which to understand the implication of climate change on these development goals and the sectors' climate change mitigation and adaptation needs.

A technology prioritisation process was conducted on a sector-by-sector basis. Through a series of technology prioritisation workshops, technologies were selected based on the country's priorities and ranked within each sector. The workshops were guided by the multi-criteria analysis (MCA) matrix to understand which climate change mitigation and adaptation technologies need to be prioritised in the context of their technological role in supporting the effective implementation of climate change initiatives in the country.

The MCA was described by Dodgson et al. (2009) and was outlined in a guideline for countries conducting a Technology Needs Assessment (Haselip et al., 2015). The MCA approach assisted in determining to what extent each potential technology contributes to national development goals, reduces GHG emissions and/or benefits adaptation, while being cost effective. The MCA approach thus provided a structured framework which allowed the comparison of a number of technologies against multiple criteria and facilitated stakeholder participation relying on the technical expertise of stakeholders.

During the updating of the Technological Needs Assessment synthesis report, an analysis to highlight the key barriers to climate technology innovation, within the key sectors prioritised, was undertaken. This focused on the identification and analysis of specific barriers to the development, transfer, diffusion and deployment or implementation of technologies for climate change mitigation and adaptation in the country.

A key input into this analysis was stakeholder input from discussions at the sectoral technology prioritisation workshops, as these workshops brought together stakeholders from various science councils, universities, national government departments and the private sector. Based on a review of the literature and technology prioritisation workshops, a barrier analysis workshop was held with key stakeholders to refine the outcomes of the analysis and to propose interventions to unlock the barriers. The following criteria were used for identifying and assessing barriers to climate technology innovation:

- Cost.
- Public policies.
- Market structure.
- Socio-economic opportunities e.g., social inclusion and creation of new jobs.
- Institutional arrangements and readiness.
- Technological readiness.

5.3.1 Technology Needs

The Technological Needs Assessment prioritised technologies and identified two sectors for mitigation and five sectors for adaptation. These technologies can be implemented in the short-to-medium term.

5.3.1.1 Technology Needs for Mitigation

In terms of mitigation, the industrial sector has the potential to implement measures to improve its energy efficiency as well as switch from using raw materials to recycled materials. These measures have significant potential to reduce GHG emissions and to also assist industries in terms of energy savings and job creation. Similarly, in the waste sector, technologies which had the most potential to reduce/avoid greenhouse gas emissions scored the highest (Table 5-13).

Table 5-13: Prioritised Technologies for The Mitigation Sector (CSIR, 2019)

Mitigation sector	Prioritised technology	Justification / motivation
Industry	Aluminium – Energy monitoring and management system	• Sector plays an important role in national economic development. • Largest contributor to GHG emissions in the industrial sector. • Improving energy efficiency could make production of aluminium more competitive.
	Utilise waste material (such as old tyres) as fuel in cement production	• Improves efficiency of cement production while reducing dependence of fossil fuels and GHGs. • Potential to supply waste energy through Combined Heat and Power combustion systems

Mitigation sector	Prioritised technology	Justification / motivation
		(CHP) and co-generation to neighbouring communities.
	Aluminium – Secondary production and recycling	• Allows for re-use of aluminium scrap. • Environmentally sound process that is more energy efficient than primary production.
Waste	Higher value and marketable byproducts from food waste	• Enterprise development and diversion of organic waste from landfill.
	Separation at source and waste recovery services by small businesses	• Increased community participation rates in recycling programs. • Sustainable job creation.
	Anaerobic digestion (Large scale)	• High mitigation potential. Production of electricity. • Solid by-products can be turned into compost and fertiliser.

5.3.1.2 Technology Needs for Adaptation

Urban forestry, conservation tillage, wetland restoration and protection and biorefinery were the technologies for the agriculture, biodiversity and forestry sector which scored the highest in addressing climate change and ecosystem benefits (Table 5-14). Organic agriculture/ farming, multiple land use and managing and monitoring invasive alien species technologies were other potential technology options to consider in the sector. The human settlement sector focused on disaster risk reduction in terms of improved stormwater drainage and the use of fire-retardant building materials, as well as low elevation engineering which provided coastal protection measures.

Low pour flush toilets, rainwater harvesting and desalination are currently being implemented across the country as the highest scoring prioritised technologies for the water sector. These technologies also have the potential to provide solutions to the challenges around water pollution and water resource availability.

Table 5-14: Prioritised Technologies for The Adaptation Sector (CSIR, 2019)

Adaptation Sector	Prioritised technology	Justification/motivation
Agriculture, Biodiversity and Forestry	Urban Forestry	• Promote adaptation to heat stress by providing shading and evaporative cooling, rainwater interception and storage and infiltration for cities. • Potential to act as carbon sinks.
	Conservation Tillage	• Reduces risk though enhanced soil-moisture retention and minimising soil impaction. • High ecosystem benefits through carbon sequestration in organic matter accumulation in the soil from use of residues and cover crops.
	Wetland restoration and protection	• High ecosystem benefits. • Contributes to water sector priorities. Potential for improved livelihoods.
	Biorefinery	• Maximises value-added products obtained from biomass through more efficient, optimised processes.

Adaptation Sector	Prioritised technology	Justification/motivation
		• Cross-cutting in agriculture, forestry, fisheries, waste and industry sectors.
Fisheries	Rapid screening tools for imported wild caught, aquaculture products and bait	• Supports rapid health assessment of wild and imported fish (and bait) in line with aquaculture requirements.
	Early warning systems for forecasting extreme events	• Supports disaster risk management and adaptive responses to extreme weather events and has the potential to save lives.
	Early warning systems to detect changes in algal blooms	• Risk reduction in terms of impact on aquatic ecosystems, human health and the economy.
Human Settlements	Disaster risk reduction: Sustainable urban drainage systems	• Improving the resilience of urban built-up environments to flooding. Enterprise development to produce sustainable urban drainage system technologies. • Job creation. • Reduce the contamination of storm water from pollutants.
	Low elevation engineering	• Job creation in the building and construction sector. • Protection of coastal zones from flooding.
	Disaster risk reduction: Fire-retardant building materials for low cost and informal housing	• Enterprise development for the formulation of fire-retardant materials and the design of fire-resistant houses. • Increase the adaptive capacity of human settlements to natural disasters.
Water	Low pour-flush toilets	• Suitable for areas with low water availability. • Water saving (uses 1 to 2 Litres per flush).
	Rainwater harvesting	• Increases diversity and optimisation of mix of water sources. • Improves the reliability of water supply in rural areas and municipalities where services are unreliable.
	Desalination technologies for brackish water, ground water, mine water and seawater	• Increases ability to make use of more sources of water. • Potential to add jobs to the Blue Economy.

5.3.2 Barriers to Climate Technology

The technologies prioritised above are discussed in this section in terms of barriers to implementation and national actions to support these technologies.

5.3.2.1 Barriers to Mitigation Technologies

The Department of Science and Technology (DST) and the Department of Environmental Affairs (DEA) identified barriers to the first cluster of mitigation technologies in the following categories: policy and regulatory, access to information, technical, research and development (R&D), cost or financial

and technology transfer barriers. Table 5-15 to Table 5-17 provide an overview of barriers to technologies in the energy, IPPU and waste sectors.

Table 5-15: Barriers to Energy-Related Mitigation Technologies Prioritised in The Department of Environmental Affairs (DEA) and Department of Science and Technology (DST) Mitigation Technology Plan (DEA and DST, 2015)

Mitigation Technology or Technological System	Description of Barriers
Carbon capture and storage (CCS)	• Lack of policy and regulatory clarity and certainty. • Insufficient knowledge of and information on, the effectiveness of the technology. • Limited domestic R&D conducted in South Africa. • Weak or limited human skills-base to support CCS development. • Underdeveloped market and private sector interest in CCS are not articulated.
Advanced biofuels	• Lack of policy and regulatory clarity and certainty. • Insufficient knowledge of and information on, the effectiveness of the technology. • Social resistance (mainly by environmental activists). • Socio-economic and environmental impacts research not well done. • The underdeveloped market for biofuels.
Smart grids	• Insufficient knowledge of and limited information on, technology (its availability and effectiveness). • Underdeveloped market and private sector investment is limited. • Poor or underdeveloped physical infrastructure for deploying the technology in rural areas.
Solar photovoltaics	• Underdeveloped human skills-base (limited number of skilled installers with technical skills). • Lack of proper standards for performance and quality management. • Relatively high installation costs for rural poor households. • Limited public information/awareness of economic and environmental benefits of the technology. • Financing of technology commercialisation is scarce or limited.
Solar water heaters	• Underdeveloped human skills-base (limited number of skilled installers with technical skills). • Lack of proper standards for performance and quality management. • Relatively high installation costs for rural poor households. • Limited public information/awareness of economic and environmental benefits of the technology.
Energy efficient lighting	• Lack of policy and regulatory clarity and certainty. • Inadequate infrastructure and accessibility of technology in rural areas. • Relatively high cost of technology for poor rural households.
Variable speed drives and energy efficient motors	• High-cost large-scale rollout. • Limited public information/awareness of economic and environmental benefits of the technology. • Lack of incentives for private investment in the development of the technology.

Mitigation Technology or Technological System	Description of Barriers
	• Underdeveloped/limited human skills-base (short supply of engineers and system designers).
Energy efficient appliances	• The relatively small market for energy efficient appliances such as refrigerators. • Limited public information/awareness of economic and environmental benefits of the technology. • High costs of acquiring the technology by rural poor households.
Energy storage technologies	• Poor knowledge of and limited information on technology (its availability and effectiveness). • Underdeveloped market and private sector investment is limited. • Poor coordination and/or linkages between R&D (e.g., CSIR) and industry (e.g., IDC).
Hybrid electric vehicles	• Limited knowledge and information (awareness) of the technology and its effectiveness and economic, as well as environmental benefits. • High upfront costs of purchasing hybrid electric vehicles. • Limited financing for domestic R&D on the technology. • Insufficient coordination between departments of transport, energy, science and technology and finance undermines efforts to develop a national policy and strategy. • Intellectual property protection (barrier to local manufacturing).
Wind (Onshore)	• Small domestic market and lack of incentives (including financing) for the private sector, particularly SMEs. • Underdeveloped manufacturing base for technology components. • Technological lock-in in coal-generated electricity by Eskom. • Lack of policy and regulatory clarity on nuclear power/energy. • Social resistance and politicisation.
Nuclear pressured water reactor (PWR	• Lack of incentives to attract domestic private sector investment. • Limited human skills-base to conduct R&D and develop as well as deploy the technology. • High costs of technology.

Table 5-16: Barriers to IPPU-Related Mitigation Technologies (CSIR, 2019)

Mitigation Technology or Technological System	Description of Barriers
Improving energy efficiency in primary aluminium products	• Limitations of the technologies used in the electrolysis process. • New equipment or changes to processes may also need to be implemented, these would be industry-site specific and could be costly. • The demand to produce more metal from existing capacity shifts the focus to increasing the electric current in the electrolytic process, rather than reducing it.
Anode technology selection for primary aluminium smelting	• Research and further investigations into the best available technology (based on the existing equipment and design) is required. • International development and testing of these new technologies are occurring, with a limited market in South Africa.

Mitigation Technology or Technological System	Description of Barriers
Switch from coal to biomass / residual wood waste in the paper and pulp industry	• The investment costs of new equipment and retrofitting boilers inhibits private sector investment.
Basic Oxygen Furnace in the production of iron and steel	• The use and installation would be subject to limitations associated with the location of existing equipment and plant design. • The cost of the system might also prevent private sector investment.
Waste material as a fuel in cement production	• Scrapped tyres are spread out across the country, so the correct procedures for collection, classification and storage are required. • Public concern about the increase in air pollution emissions and the release of toxic gases, such as dioxins, might reduce interest in such an investment.
Combined heat and power (CHP) in the paper and pulp industry	• High initial capital costs of implementing a CHP system.
Energy Management and Monitoring System	• Limited finances and awareness of the options available might make industries hesitant to invest, especially if the production process is complex. • Unless there are incentives to invest in energy efficiency, capital investment is likely to prioritise areas of the production process that require it more urgently (i.e., investments that can directly improve productivity).
Improvement of process monitoring and control	• The capital costs and the return time on investment would need to be understood to convince industries of the return on investment.
Top Gas Recycling (with CCS)	• The stage of development of such technologies and its track record might make private sector wary of investment.

Table 5-17: Barriers to Waste-Related Mitigation Technologies - Waste Sector (CSIR, 2019)

Mitigation Technology or Technological System	Description of Barriers
Recycling - Higher value and marketable by-products from food waste	• Small scale operations not practical. • Contamination of post-consumer food waste usually from packaging, household objects and non-recyclables make extraction costly. • Contamination risks of post-consumer food waste from household hazardous waste. • Lack of enforcement of separation at source of commercial food waste, especially from shopping centres and restaurants.
Recycling - Separation at source and waste recovery services by small businesses	• Enforcement of separation at source in the residential, commercial and industrial sectors is insufficient. • The informal sector, which is recognised, is left largely to operate in its current form. • Lengthy engagements with informal waste pickers to integrate them into co-operatives and small businesses have shown that the loss of revenue for pickers makes participation in the formalisation process unattractive to them. • Infrastructure and resources are lacking for the success of co-operatives, including transport, equipment, premises to work and electricity supply.

Mitigation Technology or Technological System	Description of Barriers
	• Operational challenges include theft of recycles, finding markets to sell recycles and networking. • Insufficient training of waste pickers to operate small businesses including technical, governance and business management skills. • Underdeveloped relationships between co-operatives and local government. • Lack of start-up and working capital.
Anaerobic digestion: large scale from both industrial and municipal waste	• Capital-intensive. • Source of GHG emissions. • Most organic waste ends up in landfills.
Anaerobic digestion of municipal and industrial wastewater sewage sludge with Combined Heat & Power (CHP)	• Low gas yields due to issues relating to the sludge management component of the plant can result in lower gas production than anticipated. • Human faecal waste which mixes with municipal effluent cannot be used as a feedstock since pathogen reduction by mesophilic anaerobic digestion is insufficient.
In-vessel composting	• Capital intensive. • Requires extensive training of personnel. • High maintenance and operational costs.

5.3.2.2 Barriers to Adaptation Technologies

The implementation of the technologies listed for climate change adaptation can be impeded or hindered by a range of policy, institutional, social and technical factors. There are policy and institutional issues pertaining to land and resource tenure in general. Ownership of land and land size influences technology choice and implementation. The development and implementation of some of the technologies may be impeded by lack of policy and regulatory clarity as well as social resistance. Scarcity of human resources and limited funding are impediments to R&D. Barriers to implementation of technologies may include lack of information and high costs for small-scale rural farmers. Table 42 to Table 46 below summarise the identified barriers to the adoption of adaptation technologies.

Table 5-18: Barriers to adoption of AFOLU-Related Adaptation Technologies (CSIR, 2019)

Type of technology or technological system / field	Barriers to technology development and implementation
Urban forestry and vegetation	• High implementation cost depending on location. • Some municipal laws are an impediment, particularly land tenure restricting farming practices in municipalities.
Biorefinery	• High investment costs and operational expenses. • Need for development of skills to build and operate new technologies. • R&D funding constraints.
Organic agriculture	• Inadequate incentives for implementation of organic agricultural technologies due to low potential to capitalise further investments. • Weak technical standards for inspection and certification of organic products from small-scale farmers in rural parts of the country.
Integrated pest management	• Limited technical skills among farmers, particularly in rural areas.

	• High costs of equipment and other materials for small-scale farmers in rural areas. • Low incentives, particularly for small-scale farmers, due to limited potential to capitalise new investments.
Monitoring and managing invasive species	• Limited R&D funding. • Poor institutional coordination between provinces and national government departments. • Underdeveloped public-private sector collaboration.

Table 5-19: Barriers to adoption of Fisheries-Related Adaptation Technologies (CSIR, 2019)

Type of technology or technological system / field	Barriers to technology development and implementation
Technologies for the rapid health assessment of wild and imported fish (and bait)	• Additional research and development are needed for application in the local context. • Protocols and training of customs/airport staff in aquatic health and hazards. • Training needed in local labs.
Early warning systems for forecasting extreme events	• R&D funding constraints. • User confidence in the degree of uncertainty.
Early warning systems for detecting changes in algal blooms	• R&D funding constraints. • Availability of good quality real-time data may be limited. • User confidence in the degree of uncertainty. • Methods for communication of information to users and ownership of management i.e., who will manage system?

Table 5-20: Barriers to adoption of Water-Related Adaptation Technologies (CSIR, 2019)

Type of technology or technological system / field	Barriers to technology development and implementation
Rainwater harvesting	• High cost to install across income groups. • Lack of incentives for broader adoption.
Desalination	• High infrastructure investment. • High financial viability and operational efficiency to be a successful alternative water supply. • High maintenance costs. • Energy-intensive. • Requires skilled personnel.
Protecting and restoring ecological infrastructure	• Need for secure financial flows for restoration and ongoing maintenance of ecological infrastructure. • Need for improved institutional capacity for investment in ecological infrastructure. • Competition for land.
Reducing system leakages	• Need for area-specific assessments and interventions – municipality needs vary depending on the root causes of water losses. • Lack of capital in most municipalities to buy the technology (models/software and training costs). • Lack of implementation of the policies and regulations which are already in place when it comes to leak detection.
Low pour-flush toilets	• Needs a reliable water supply – assessment of the reliability of water supply must be done prior to implementation.

Type of technology or technological system / field	Barriers to technology development and implementation
	• Local authorities must clarify the responsibilities of operation and maintenance. • Need for plans by municipalities for disposal of leach pits. • Assessment of suitability needed in areas with high water table or sensitive ecosystems.

Table 5-21: Barriers to adoption of Settlements-Related Adaptation (CSIR, 2019)

Type of technology or technological system / field	Barriers to technology development and implementation
Disaster risk reduction - Improved stormwater drainage systems/upgrade	• High investment costs and low availability of expertise required to successfully implement upgrades. • Depending on the level of existing infrastructure in an area, implementation could be expensive, for example, in an area with little existing infrastructure that is compatible with new technology.
Low elevation engineering	• The cost of construction of options such as new groynes or well-designed seawalls may limit the use. • A further barrier may be the availability and cost associated with the specialised equipment and contractors needed for processes such as dredging. • Some dune management options may have a requirement of an Environmental Impact Assessment before commencement resulting in additional cost and lengthier timeframes. • Gaining buy-in from the public and municipal officials for the need for artificial dune creation or dune rehabilitation projects.
Disaster risk reduction - fire-retardant building materials for low cost and informal housing	• Typically undertaken as pilot projects – highlighting the need for • innovation and markets for affordable materials to be developed. • Require community-civil society-government-private partnerships to roll out innovative upgrades to existing settlements.
Energy efficiency (e.g., combined heat and power; smart grids, smart cities)	• Capital and operational and maintenance costs are high. • The costs to maintain the system and the availability of existing skills to use the technology could lead to resistance/lack of buy-in. • In cities that are cash-strapped there may be a lack of political support in terms of providing financial support.
Climate adaptive buildings	• Limited low-cost adaptation measures and regulations/codes to enforce implementation of adaptation options. • Limited skilled capacity (engineers, architects and builders, inspectors) to develop standards and to enforce standards. This can increase the difficulty of implementing adaptation measures. • Enforcement procedures of national building regulations and local by-laws are sometimes limited or non-existent within local municipalities. • The availability of suitable materials at an affordable cost.

Table 5-22: Barriers to adoption of Infrastructure-Related Adaptation (CSIR, 2019)

Type of technology or technological system / field	Barriers to technology development and implementation
Heat resilient surfaces (e.g., warm mix asphalt and engineered cementitious composite	• Capital scarcity for long-term capital-intensive investments. • South Africa's investment in R&D has been in steady decline. • The railway capacity is insufficient to support the transportation of large quantities of raw materials and recycled materials needed to produce new types of concrete and asphalt. • High transport and labour costs. • Volatility and low productivity of the workforce. • Shortage of skilled workers that can support the deployment of new concrete and asphalt technologies. • Slag by-product from manganese alloy production is classified as a hazardous material and cannot be sold in South Africa but could be used in new asphalt mixes

5.4 Needs, Constraints and Gaps in Other Activities Relevant to Climate Change Response in South Africa

5.4.1 Integration of Climate Change Concerns into Sustainable Development Programs

The integration of climate change considerations into municipal development planning tools such as the IDPs and Spatial Development Plans (SDPs) remains limited and requires more attention and strategic assistance from provincial and national government.

Furthermore, technical and capacity building support for technological innovation around social-ecological systems and sustainability forms part of the gaps for integration of climate change concerns into sustainable development programs. Further, support on resources as the socio-economic consequences of COVID-19 are uncertain, it is very likely that South Africa will be more indebted than prior to the crisis, which will add strain to both the South African fiscus and the local capital markets and potentially increase the cost of borrowing.

5.4.2 Research and Systematic Observations

Large scale interdisciplinary, multisite and multiscale programmes are needed to address integrative climate change research needs. One of the leading challenges for research and systematic observations is the insufficient financial resources to fund research projects, systematic observation programmes and early warning systems, which prevents South Africa from conducting it at a comparable level to that of other nations (Ziervogel et al., 2022). As a result, there are fewer research projects that can be carried out in South Africa and there is a shortage of data and information about the effects of climate change in the region.

Another barrier is a lack of capacity and knowledge in the field of climate change. To increase capacity, more public financing and enhanced private sector investment are required for research, routine observation and early warning systems.

There are also technical barriers to research, as there is a lack of trained personnel to handle the specialised equipment required to conduct research, systematic observation and early warning systems. Additionally, there are few organisations and researchers working on climate change research in South Africa and these organisations may not consistently have the capacity to keep abreast of the most recent developments in the field (ASSAf, 2019). As a result, developing strategies using evidence-based decision-making to mitigate climate change has not yet been implemented. The effects of climate change and the need for research to understand these implications and develop

solutions are not well known in South Africa. The development of public policy to address climate change has been hampered by this lack of knowledge. Therefore, training and capacity development is required to ensure that the country has the necessary competence to establish and sustain these systems.

Furthermore, South Africa must invest in infrastructure maintenance and improvement, to guarantee that the country has the means to support climate-related research. This extends to universities and other South African institutions, which lack the necessary resources to address the needs of the nation in terms of research and systematic observation.

There is also a lack of coordination among the various research institutions and programmes in the country (Razzano, 2016). This has prevented the development of successful strategies to manage climate change and has resulted in a lack of research integration. To ensure that South Africa can successfully manage climate change-related impacts, it is necessary to overcome these limitations and gaps in the nation's research programmes connected to climate change. Thus, inter-institutional collaboration is required to strengthen the country's research capabilities.

Lastly, establishing a legislative framework in South Africa is necessary to guarantee that research, systematic observation and early warning systems are created and maintained in accordance with international standards.

5.4.3 Education, Training and Public Awareness

The most notable challenge identified when compiling information on climate change education, training and public awareness for this national communication, was the limited information on climate change education in South Africa. Secondly, the initiatives undertaken to promote climate change awareness are not easy to identify as information is scattered per institution. Therefore, to enable systematic upscaling, coordination and extension of climate change education and training efforts, there is a need for improved coordination between institutions (Maponya and Lotz-Sisitka, 2022).

Greater collaboration and engagement between government agencies working on both scientific and practical climate change responses, such as the Departments of Forestry, Fisheries and the Environment, Science and Innovation, Basic Education and Higher Education and Training, are also seen as necessary. Third, South Africa lacks a dedicated strategy for communicating and educating about climate change. Fourth, there is no information regarding the inclusion of climate change content in other subjects, with the climate-resilient development pathway of the National Climate Change Response White Paper not being incorporated in the curriculum. The geography curriculum for Grades 10–12 carries the most substantial content on climate change education in the Curriculum Assessment Policy Statements (CAPS) curriculum. Furthermore, neither climate change, nor the problems it raises, are substantially addressed in South Africa's National Policy Framework for Teacher Education and Development and there are no policies governing where or how climate change subjects should be integrated into teacher education. Environmental issues are not mentioned in South Africa's Department of Higher Education and Training Strategy Plan (2020-2025). Nonetheless, there is limited amount of information available on CCE policies and practises across other countries as well.

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6 Annexures

6.1 Annexure 1: Government of Flanders Funded projects in South Africa

Name of Organisation	Name of Project and Location	Brief Project Description
Indalo Inclusive	Reaping the potential of entrepreneurship for a climate-smart inclusive green economy in South Africa	Climate-smart enterprises providing market-based solutions which help to enhance the adaptive capacities of the South African economy and society hold an immense potential to help South Africa achieve its NDC targets and to move towards an inclusive green economy (IGE). However, climate-smart enterprises are facing various obstacles, specifically: a) lack of information on vetted business models & adaptation technologies and tailored advisory services b) unavailability of support mechanisms and financing instruments and c) unfavourable policies. The programme addresses these problems through an innovative and holistic approach by systematically and continuously strengthening capacities, organisational resilience and sustainability impact potential of climate-smart enterprises while promoting the relevance of climate change adaptation (CCA) and entrepreneurial solutions among key stakeholders.
VVOB education for development	Keep it Cool Climate Change Education	To utilise the education sector as a strategic resource in South Africa's transition towards a more climate resilient society. Secondary schools in KZN, Eastern Cape and Limpopo address climate change through education supported by multiple actors at national, provincial and district level.
GenderCCSA	Building resilience and reducing vulnerability of smallholder farmers by focusing on mango farming enterprises, water and eco-system-based services to reduce the negative impacts of climate change	This project aims to build resilience and reduce climate vulnerability by focusing on critical sectors such as water and ecosystem resource, energy and agriculture, in order to reduce the negative impacts of climate change and improve the resilience of these communities. It will seek to increase climate resilience by working directly with local communities, municipalities, stakeholders and anticipated beneficiaries through the implementation of adaptation projects in each of the geographical areas selected. The focus of the project will be policy, research and implementation.
Olive Leaf Foundation	Communal Agricultural Transformation (CAT) – Empowering people Restoring Land	The project is a dynamic collaboration between OLIVE LEAF Foundation (OLF) and the Savory Institute (SI), each bringing unique strengths and expertise to the partnership. OLF is a South African Sustainable Development Organisation with 30 years' experience in social development and community mobilisation across Africa. SI is an international organisation, and its core focus is addressing climate change and land degradation through training and education, using Holistic

Name of Organisation	Name of Project and Location	Brief Project Description
		Management© (HM) as the main tool to equip individuals and communities. SI supports a worldwide agricultural movement that regenerates soil, rebuilds communities, and increases biodiversity.
Wildlands Conservation Trust	Enabling community-based adaptation in the Mkhuze River Ecosystem, KZN	The primary objective of the project is to enable rural communities to adapt to climate change impacts. This will be done through climate smart and conservation agriculture techniques, strengthening of local governance structures (focusing specifically on women in leadership positions), local restoration activities and the development of the green economy. This will develop resilience at a community level that will promote sustainable development, ensure food security, enable the conservation of the natural environment and secure the flow of critical Ecological Goods and Services to local communities. The project will be implemented along the Mkhuze River in northern KwaZulu-Natal.
Belgium Campus iTversity	Micro-aquaponics Lappies – Proof of concept of community embedding	The project aims at the sustainable community-based implementation of modular smart solar aquaponics systems. Through field validation, the project will: 1. stimulate and facilitate the adoption of the technology; 2. deliver a step-by-step guide to design, implement and monitor the community-based embedment of modular smart aquaponics systems as a methodology to strengthen the micro-economic activity in the green economy and climate change adaptation of South Africa. As an innovative integrated technological concept, the aquaponics system will contribute to 1. climate-smart agriculture; 2. ecosystem-based adaptation; 3. agricultural extension; 4. community-based adaptation; 5. research and development. In gaining community embedment experience, the project will contribute to ICT smart agriculture, communities' human, social, knowledge and build capital. It is expected that this will spontaneously lead to community-based business development, enhancing sustainable economic and social impact, equity and fairness, and food security in support of climate-change adaptation.
Kruger to Canyons Biosphere Region NPC (K2C)	Towards an inclusive green economy: Showcasing sustainable land use management projects in the Kruger to Canyons Biosphere Region	The overarching aim of the project is to support the development of economic opportunities for local people as part of an inclusive green economy. This will be achieved by supporting climate smart agriculture (agroecology), sustainable rangeland management and water stewardship. The project aims to work with approximately 250 livestock and crop farmers of the Bapedi Ba Dinkwanyane people who practice subsistence and semi-commercial forms of agriculture directly adjacent to one of South Africa's most iconic nature reserves, the Blyde River Canyon (BRCNR).
WWF South Africa	Building climate resilience of coastal communities, ecosystems and small-scale fishers through	To build climate resilience of coastal communities, ecosystems and small-scale fishing communities through implementing participatory and integrated community and ecosystem-based adaptation (EBA) and ecotourism activities to improve food and livelihood security. To implement community and

Name of Organisation	Name of Project and Location	Brief Project Description
	implementing community and ecosystem-based adaptation activities and diversifying livelihoods	ecosystem-based adaptation activities with Kleinmond and Hamburg rural coastal communities located in the Western Cape (WC) and Eastern Cape (EC) provinces respectively, through raising awareness, capacity building and skills development to enhance food security and sustainable livelihoods.
UN Environment	Increasing Resilience and Reducing Vulnerabilities of Local Communities to the Effects of Climate Change: Promoting Ecosystem Based Adaptation in South Africa	Despite a comprehensive nationally planned response to climate change, gaps exist around implementation, which the proposed 2-year project will address through technical assistance to South African EbA planning, implementation and monitoring. Four work packages focus on the themes of (1) capacity building, (2) finance for Eba; (3) coordination and networking; and (4) a small grants facility designed to catalyse innovation at local level and facilitate the replication and/or scaling of climate change actions that work.
Department of Environment Forestry and Fisheries- Adaptive Capacity Facility	DEFF Adaptive Capacity Facility: implementing 3 Climate Change Adaptation projects in District Municipalities	The South African Department of Environment, Forestry and Fisheries (DEFF) in partnership with the Government of Flanders has developed the “DEFF Adaptive Capacity Facility” (DEFF-ACF or ACF). The key challenge the ACF aims to address is the lack of effective climate change implementation at a local level in South Africa. The Facility is intended to benefit those citizens and communities of South Africa that are most vulnerable to climate change impacts as a result of their exposure to various impacts and/or their lack of capacity to adapt to these impacts. These vulnerable groups are most reliant on effective institutional adaptation measures that can reduce their exposure to the impacts of climate change and increase their adaptive capacity to more effectively respond to climate change.
South African National Biodiversity Institute	Unlocking Climate Finance for Climate Change Adaptation	The Direct Access modality is an exciting finance mechanism of the Green Climate Fund (GCF) whereby national and regional institutions are afforded the opportunity to become accredited with the Fund, and to lead project development and subsequent oversight processes in their countries. A major constraint of the approach is the need to build capacity in these newly accredited institutions while they are developing their proposals, and before their projects are funded. While the GCF offers significant technical capacity building opportunities for Direct Access Entities, limited core institutional capacity within Direct Access Entities often makes it difficult for these entities to take advantage of this. SANBI is well placed to develop a pipeline of GCF projects that meet with the funding criteria of the Fund and deliver on national priorities for climate change adaptation. It has, however, been constrained in its ability to capitalise on this opportunity. SANBI is supported by the Government of

Name of Organisation	Name of Project and Location	Brief Project Description
		Flanders (GoF) to assist it to develop a funded portfolio of GCF projects over the next four years through capacity building.
United Nations Educational, Scientific and Cultural Organisation	Addressing Climate Risk and Building Adaptive Capacity in South Africa's Biosphere Reserves: Towards Sustainable Water and Ecosystem Management	The severe impacts of prolonged droughts in South Africa over the last decade highlight the vulnerability of the country to water scarcity, a condition which is expected to worsen considerably as a result of climate change impacts. The analysis after almost reaching 'Day Zero' in Cape Town, indicates a clear need to include climate change impacts in medium to long term water planning, and to move towards ecosystem-based adaptation that ensure long-term sustainability. The proposed project addresses this gap by introducing a novel bottom-up, participatory approach to climate change adaptation, providing an adequate planning pathway for decision making at the local, regional and national level. In combination with adequate monitoring and early warning tools, climate informed decision-making is significantly facilitated. Targeted training and technology transfer will further ensure that the capacities to develop effective ecosystem-based adaptation strategies are strongly enhanced.
South African Weather Services	An Integrated Climate-driven Multi-Hazard Early Warning System (ICMHEWS)	The South African Weather Service (SAWS) is well poised to play a central role in the development and operationalization of an Integrated Climate-driven Multi-Hazard Early Warning System (ICMHEWS) given that it is the national custodian of climate data in South Africa. The main goal of the proposed project is to develop a robust and user-inspired (people & communities) climate-driven multi hazard early warning system which incorporates tenets such as near-real time multi-risk knowledge co-generation & co-production, public education and awareness of risks, dissemination of impact-based messages and warnings efficiently, a constant state of preparedness and enabled early action as well as monitoring and evaluation. The ICMHEWS is aimed at supporting the district municipalities to become resilient to climate-driven shocks. In this regard, it is expected that all the relevant climate-sensitive sectors including bioeconomy, agriculture, water, energy, health, housing, transport, business, and general public will benefit from the proposed project. The target groups for the ICMHEWS comprise of the community of practice within the weather and climate enterprise such as government departments, academic and research institutions, private sector, media, NGOs as well as international & multinational organisations.
Water Research Commission	Adaptive response and local scale adaptation for improving water security and increasing resilience to climate change in selected	The Water Research Commission hosts a climate change flagship programme which is implemented through collaborative research and development on priority water-related climate issues with partnerships forged along the innovation value-chain to enhance water research and development nationally and globally. It focuses on ensuring empowerment of people for enhanced resilience, and development of the knowledge base for climate adaptation and decision support tools, together with

Name of Organisation	Name of Project and Location	Brief Project Description
	municipalities of South Africa.	guidance and frameworks for sectoral response. Water is critical for development, economic growth and a better life. It is a key factor for inter-sectoral linkages. Climate change impacts on water resources and development cannot be underestimated. Increased occurrence of extreme climatic events brings about negative implications for infrastructure, health, production and economic growth, amongst others. This proposal brings to attention a focus on measures that will increase the resilience of the water-linked sectors and implement adaptive response strategies in order to improve and sustain the water sector's adaptive capacity to deal with the future climate, while covering a complete spectrum from rural, peri urban to urban areas. The purpose is to provide practical adaptive solutions (tested and experimented through research and practice) to the deal with the consequences of climate change in rural communities and municipalities with rural-urban interface.

6.2 Annexure 2: SANBI's Green Climate Fund (GCF) and Adaptation Fund (AF) project proposal pipeline (October 2023)

Project theme	Proposed project value, lead partners and geographic scope	Timeline
#1. Scaling up Ecosystem-based Approaches to managing climate-intensified disaster risks in vulnerable regions of South Africa (Eco-DRR). • Original Expression of Interest submitted by DFFE-Natural Resource Management. • Please see **Section 6.2.16.2.1** for an overview of the Eco-DRR project.	• Value: ~USD30 million grant from the GCF; ~USD20 million local co-finance • Lead partners: Department of Environment, Forestry and Fisheries – Environmental Programmes (DEFF-EP), National Disaster Management Centre (NDMC) and target District Municipalities • Geographic focus: National. Project Target Areas (District Municipalities) are noted below. Specific Implementation Sites will be determined during the development of the full Funding Proposal, based on vulnerability to climate change induced/ exacerbated flood, fire and drought. The selected Provinces and Districts are: o Limpopo Province: Sekhukune District Municipality; o Mpumalanga Province: Ehlanzeni District Municipality; o North West Province: Ngaka Modiri Molema District Municipality; and o Eastern Cape Province: Alfred Nzo and Joe Gqabi District Municipalities.	• Concept Note: endorsed November 2019. • Project Preparation Facility (PPF) phase: initiated February 2022. • Funding Proposal: submitted to GCF 31 March 2023; Planned for resubmission by 31 March 2024.
#2. Ecosystem-based Approaches for transforming smallholder farming systems that are vulnerable to the impacts of climate change in South Africa. • Original Expression of Interest submitted by University of KwaZulu-Natal (UKZN), as an upscale of the uMngeni Resilience Project funded by the Adaptation Fund. • This project will include elements of an Expression of Interest submitted by the (then) Department of Agriculture, Forestry and Fisheries entitled: A project that seeks to mainstream Climate Change into South Africa's Early Warning System for pests and diseases. • Please see **Section 6.2.2** for an overview of the EbA-Farm project.	• Value: ~USD25 million grant from the GCF; ~USD20 million local co-finance (Project to be developed through the GCF's Simplified Approval Process mechanism) • Lead partners: Roles of the Department of Agriculture Land Reform and Rural Development (DALRRD); the Eastern Cape, KwaZulu-Natal, Limpopo and Mpumalanga Provincial Departments of Agriculture; and other lead partners will be determined during the development of the full Funding Proposal. • Geographic focus: National The project will be implemented in the Eastern Cape, KwaZulu-Natal, Limpopo and Mpumalanga Provinces. Target catchments and specific implementation sites within the target catchments will be determined during the development of the full Funding Proposal.	• Concept Note: 3rd revision was endorsed in October 2021. • PPF phase: consultants contracted May 2023. • Funding Proposal: To be submitted to the GCF by 31 August 2024.

#3. Ecosystem Based Adaptation for Water Security in South Africa (EbA-Water). • This project will build on Global Environment Facility (GEF) investments in SANBI's Biodiversity and Land Use and Ecological Infrastructure for Water Security Project projects. • This project emerged from project #6, which proposed securing Strategic Water Source Areas (SWSAs) in Mpumalanga Province. This project takes this to a national scale noting that securing SWSAs is a DFFE and Department of Water and Sanitation (DWS) delivery priority. • Please see **Section 6.2.3** for an overview of the EbA-Water project.	• Value: ~USD25 million grant from the GCF; ~USD20 million local co-finance (Project to be developed through the GCF's Simplified Approval Process mechanism) • Lead partners: DFFE, Department of Water and Sanitation (DWS) and SANBI • Geographic focus: To be confirmed during full Funding Proposal development	• Concept Note: 6th revision endorsed in July 2023. • PPF phase: application submitted to GCF in Oct 2023. Anticipated that consultants will be contracted by GCF in early 2024. • Funding Proposal: *Tentatively anticipated* to be submitted by March 2025.
#4. Enhancing South Africa's Community Adaptation Small Grants Facility. • Concept Note in development for submission to the Adaptation Fund.	• Value: ~USD5 million • Lead partner: SANBI • Geographic focus: National	• Concept Note: date of Submission to Adaptation Fund: TBC. • Funding Proposal: TBC.
#5. A coastal Ecosystem-based Adaptation (EbA) / Ecological Infrastructure (EI) project that incorporates natural and built infrastructure. • Original Expression of Interest submitted by the Department of Forestry, Fisheries and the Environment – Oceans and Coasts Branch.	• Value: To be determined • Lead partners: DFFE-Oceans and Coasts and coastal Provinces and Metros • Geographic focus: coastal Provinces	• Concept Note: date of Submission to GCF: TBC. • PPF phase: TBC. • Funding Proposal: TBC.
#6. Aquifer recharge project focusing on EI and the enhancement of natural recharge mechanisms. • Original Expression of Interest submitted by the Western Cape Department of Environmental Affairs and Development Planning.	• Value: To be determined • Lead partners: DEA&DP and other Provinces (to be determined • Geographic focus: Western Cape and North West – to be confirmed	• Concept Note: date of Submission to GCF: TBC. • PPF phase TBC. • Funding Proposal: TBC.
#7. Improving adaptive capacity and resilience for two Districts, Gert Sibande and Nkangala District	• Value: To be determined • Lead partner: Mpumalanga Province with support of WWF-SA	• Concept Note: date of submission to GCF: TBC

Municipalities and their people through landscape-based jobs and livelihoods, driving a Just Transition in Mpumalanga Province. • Original Expression of Interest submitted by Mpumalanga Province and WWF-SA.	• Geographic focus: Mpumalanga Province, Nkangala District (to be confirmed)	• PPF phase TBC. • Funding Proposal: TBC
#8 Adaptation Fund (AF) project to strengthen Early Warning Systems maintained by South African Weather Service (SAWS)	• Value: To be determined • Lead partner: South African Weather Service (SAWS) • Geographic focus: To be determined	• Concept Note: date of submission to AF: TBC. • Funding Proposal: TBC.

Note: The GCF projects below (i.e. #s 1-3 and 5-7) emanate from the shortlist of project themes selected from the ideas submitted in response to SANBI's nation-wide call for Expressions of Interest against SANBI's GCF Funding Framework, after a rigorous review and selection process that included the inputs of relevant sector representatives and technical specialists.

6.2.1 Project Overview – Scaling up ecosystem-based approaches to managing climate-intensified disaster risks in vulnerable regions of South Africa (Eco-DRR project)

Background Information:

South Africa is highly vulnerable to the impacts of climate variability and change, increasing the frequency and severity of floods, droughts and wildfires. This threatens the ecosystems that underpin rural livelihoods and the economy. Well-managed ecosystems have the potential to reduce the severity and risk of these extreme events, especially for vulnerable rural communities.

As a Direct Access Entity of the Green Climate Fund (GCF), SANBI is preparing a full project proposal to the GCF. Entitled 'Scaling up ecosystem-based approaches to managing climate-intensified disaster risks in vulnerable regions of South Africa' (Eco-DRR project), the project aims to scale up ecosystem-based approaches to managing climate intensified disaster risks in vulnerable regions of South Africa. The project owners are the Department of Forestry, Fisheries and the Environment (DFFE) and the National Disaster Management Centre (NDMC). A consortium of service providers, led by Pegasys, has been appointed to undertake the proposal development process, which is set to run until end March 2023.

A set of 5 District Municipalities in 4 Provinces form the focus of proposal development activities. Implementation sites within these areas will be confirmed during this proposal development phase. The selected Provinces and Districts are:

- Limpopo Province: Sekhukune District Municipality;
- Mpumalanga Province: Ehlanzeni District Municipality;
- North West Province: Ngaka Modiri Molema District Municipality; and
- Eastern Cape Province: Alfred Nzo and Joe Gqabi District Municipalities.

The project will focus on the interface between natural areas and settlements, and where the condition of these areas directly affects the ways these settlements and their communities are affected by climate change.

Project Objective:

The project objective is that *ecosystem-based approaches to Disaster Risk Reduction reduce the impacts of climate change intensified floods, fires and droughts*.

Indicative Project Components and Outputs (copied from the Concept Note):

Components	Outputs
Component 1: Rehabilitation of vulnerable catchments and landscapes to reduce drought, flood and wildfire risk	Output 1.1: Climate risk management better integrated into policy and planning for landscape rehabilitation and management
	Output 1.2: Community vulnerability reduced through large scale and integrated rehabilitation of catchments (quinary) in focal landscapes
	Output 1.3: Rehabilitated catchments and landscapes maintained and managed for sustained risk reduction
Component 2: Integration of ecosystem-based approaches into settlement planning and disaster risk reduction and preparedness to build resilience	Output 2.1: Disaster preparedness for drought, flood and wildfire improved in vulnerable settlements in focal landscapes
	Output 2.2: Ecosystem-based and grey-green approaches integrated into policy and planning for National, Provincial and Municipal disaster risk reduction
Component 3: Upscaling of pathways for integrated and transformative ecosystem-based approaches to climate-intensified disaster risk reduction	Output 3.1: New and existing public and private financing mechanisms unlocked to sustain and up-scale Eco-DRR
	Output 3.2: Evidence base for Eco-DRR developed and shared

6.2.2 Project overview – Ecosystem-based approaches for transforming smallholder farming systems that are vulnerable to the impacts of climate change in South Africa (EbA-Farm project)

Background Information:

South African smallholder farmers rely on rainfall. Climate change is resulting in increased rainfall variability, which makes it difficult for smallholder farmers to plan. This is compounded by a lack of access to climate-risk informed agricultural advisory services to enhance their adaptive capacity. Existing vulnerabilities at the smallholder level are therefore exacerbated, often where agriculture is a vital source of livelihoods. Climate-resilient agriculture can be used to strengthen smallholder food systems (crop and livestock) to enhance the resilience of smallholder farmers in high-risk areas and improve yield and productivity.

As a Direct Access Entity of the Green Climate Fund (GCF), SANBI is preparing a full project proposal to the GCF for the project titled 'Ecosystem-based approaches for transforming smallholder farming systems that are vulnerable to the impacts of climate change in South Africa' (EbA-Farm). The proposed design of the project will see an upscale of successful elements of the uMngeni Resilience Project, funded by the Adaptation Fund, which has demonstrated that integrated approaches at different scales (homestead, farm and landscape) are a systematic response to building resilience and supporting socio-economic development.

A team of consultants led by Oxford Policy Management Limited and One World Sustainable Investments has been appointed by the GCF to undertake the proposal development process, which is set to run until end August 2024.

Four provinces will form the focus of proposal development activities. Implementation sites within these provinces will be identified and confirmed during the proposal development phase. The proposed provinces are:

- KwaZulu-Natal Province
- Limpopo Province
- Mpumalanga Province
- Eastern Cape Province

Project leads and their roles and responsibilities will be identified through the proposal development process.

Project Objective:

The project objective is to adopt a participatory, action-learning approach using ecosystem-based approaches to enhance the resilience of smallholder farmers in vulnerable catchments of KwaZulu-Natal, Eastern Cape, Mpumalanga and Limpopo in South Africa.

Indicative Project Components and Outputs (copied from the Concept Note):

Components	Outputs
Component 1: Provision of climate information and services to smallholder farmers in target catchments to support decision-making to build resilience	Output 1.1: Increased access to tailored climate information and services
	Output 1.2: Improved risk knowledge and awareness of climate hazards and threats
	Output 1.3: Improved climate change adaptation response capabilities
Component 2: Integration of ecosystem-based approaches to transform smallholder farming systems to adapt to climate impacts and sustain adaptation investments through enhanced market access	Output 2.1: Sustainable, healthy, and resilient food systems and agro-ecologies that are resilient to the impacts of climate change
	Output 2.2: Sustainable livelihood outcomes
	Output 2.3: Strengthened household food and water security
Component 3: Upscaling of transformative approaches- the development of cross-cutting capacity to sustainably embed and upscale transformative adaptation approaches	Output 3.1: Enhanced climate change adaptation capacity at Provincial and Local government levels across sectors that support smallholder farmers
	Output 3.2: Mainstreaming of transformative adaptation approaches into the agricultural sector bottom-up from the smallholder level
	Output 3.3: A project sustainability plan developed with stakeholders, and reviewed on an annual basis

6.2.3 Project overview – Ecosystem-based adaptation for water security in South Africa (EbA-Water project)

Background Information:

South Africa is a water scarce country facing an escalating water crisis due to climate change. Diminishing water security has negative impacts on economic growth and human well-being. South Africa has identified 22 Strategic Water Source Areas (also known as Water Towers) which collectively cover 10% of the land but provide 50% of the water supply. Strategic Water Source Areas are threatened by climate change, land degradation, unsustainable land-use practices and other factors. Currently, despite their importance, only 13% of Strategic Water Source Areas are formally protected. Existing regulatory and planning frameworks are insufficient, and institutional capacity is limited, hindering the adoption of a coordinated, climate-responsive approach to managing these areas.

As a Direct Access Entity (DAE) of the Green Climate Fund (GCF), SANBI is preparing a full project proposal to the GCF for the project titled 'Ecosystem-based Adaptation for water security in South Africa' (EbA-Water). The project aims to directly improve the security of 11 of these Strategic Water Source Areas, through a suite of complementary measures, including ecological measures (Ecosystem-based Adaptation measures), legislative and regulatory measures as well as the establishment of effective monitoring capability. SANBI will serve as the project's Executing Entity in partnership with the National Department of Forestry, Fisheries, and the Environment (DFFE) and the National Department of Water and Sanitation (DWS).

The proposed design of the project will see an upscale of successful elements of SANBI's Global Environment Facility (GEF) projects. These are the 'Mainstreaming Biodiversity into Land Use Regulation and Management at the Municipal Scale' project (GEF 5) and the 'Unlocking Biodiversity Benefits through Development Finance in Critical Catchments' project (GEF 6).
Specifically, 11 priority Strategic Water Source Areas located within 6 provinces of South Africa will form the focus of proposal development activities. Implementation sites within these proposed provinces are still to be selected, and will be based on the high level of downstream dependence on water, ecological condition, development pressure, protection levels, biodiversity importance, and the existence of related programmes in the area.

Project Objective:

The project objective is to adopt a risk-informed approach to Integrated Water Resource Management (IWRM) that advances resilience by appraising climate risks and fostering Ecosystem-based Adaptation measures to address climate change vulnerabilities and impacts in South Africa.

Indicative Project Components and Outputs (copied from the Concept Note):

Components	Outputs
Component 1: The security of Strategic Water Source Areas is improved through governance and decision-making frameworks	Output 1.1: Strategic Water Source Areas are mainstreamed into legislative, institutional, and regulatory systems and frameworks
	Output 1.2: Strategic Water Source Areas are mainstreamed into development, land use and protected area planning and decision-making
Component 2: Strategic Water Source Areas are more resilient to the impacts of climate change, and continue to provide year-round good quality water	Output 2.1: Climate-responsive, inclusive and integrated landscape management plans developed and implemented in Strategic Water Source Areas
	Output 2.2: Climate-resilient rural livelihoods are enabled through sustainable land use practices
	Output 2.3: Additional resources leveraged for sustained climate-responsive management of Strategic Water Source Areas
Component 3:	Output 3.1: Monitored and evaluation, risk assessments and natural capital accounts inform management approaches

National and sub-national institutions are strengthened to address climate risks associated with Strategic Water Source Areas	Output 3.2: Knowledge products and tools support scaling and replication of climate-responsive Integrated Water Resource Management
	Output 3.3: Enhanced institutional capacity enables sustained implementation of climate-responsive IWRM