SOUTH AFRICA'S FIRST BIENNIAL TRANSPARENCY REPORT (BTR1) TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC), UNDER THE PARIS AGREEMENT

DEPARTMENT OF FORESTRY, FISHERIES AND THE ENVIRONMENT

FIRST-ORDER DRAFT

October 2024

Executive Summary

ES.1 National GHG Inventory Summary

ES1.1: Introduction

A summary of the National Greenhouse Gas (GHG) Inventory for South Africa is presented in this report. The Inventory covers the period of 2000 to 2022 and the GHG emissions are reported under five sectors: Energy; Industrial Process and Product Use (IPPU), Agriculture, Land Use, Land Use Change and Forestry (LULUCF) and Waste. In South Africa's previous inventory, Agriculture and LULUCF were grouped together under the Agriculture, Forestry and Other Land Use (AFOLU). As the country is transitioning to the Enhanced Transparency Framework (ETF) Common Reporting Tables (CRT) reporting format, Agriculture and LULUCF are treated as separate sectors with the categories and sub-categories following those outlined in the CRT formats.

ES.1.2 Institutional arrangements

The Department of Forestry, Fisheries and the Environment (DFFE) is responsible for the co-ordination and management of all climate change-related information, including mitigation, adaption, monitoring and evaluation, and GHG inventories. The DFFE therefore played a lead role in the compilation, implementation and reporting of the national GHG inventory, with other relevant agencies and ministries providing support through the provision of data used in the inventory. The compilation of the inventory is further supported by the National Greenhouse Gas Emission Reporting Regulations, 2016 under Notice No. 275 in the Gazette No. 40762 of 03 April 2017 (DEA, 2017a) and the South African Greenhouse Gas Emissions Reporting System (SAGERS).

ES1.3 Summary of national emission and removal trends

GWP

In this inventory the emissions for each of the major GHGs are presented as carbon dioxide equivalents (CO_2e) using the 100- year global warming potentials (GWPs) from the 2014 IPCC Fifth Assessment Report (AR5) (IPCC, 2014b).

Gas trends

Carbon dioxide (CO_2) is the largest contributor to South Africa’s emissions (Figure ES1.1). CO_2 emissions contributed 81.9 % (excl. LULUCF) to South Africa’s emissions in 2022. The contribution from methane (CH_4) have increased from 12.9% to 13.2% (excl. LULUCF) between 2000 and 2022. Nitrous oxide (N_2O) emissions increased from 3.56% to 3.63% (excl. LULUCF) between 2000 and 2022. Fluorinated gases (F-gases) emissions have increased from 0.2% to 1.3% (excl. LULUCF) between 2000 and 2022. CO emissions varied between 414 Gg CO to 1 335 Gg CO between 2000 and 2022. The NO_x emissions were between 31 Gg NO_x and 60 Gg NO_x, while NMVOCs were between 5 Gg NMVOCs and 90 Gg NMVOCs over the period 2000 to 2022.

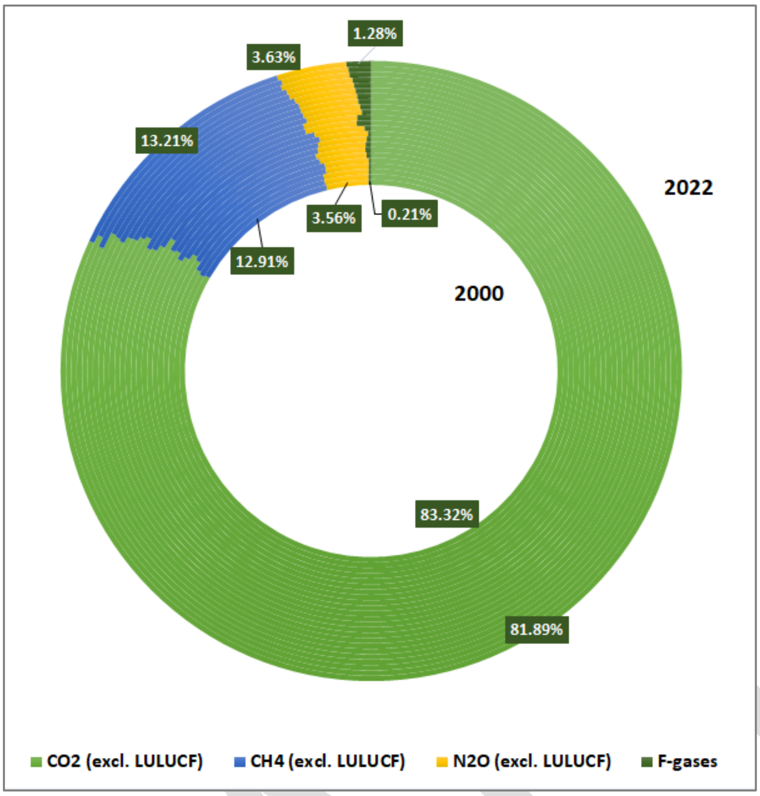

Figure ES 1.1: Gas contribution to South Africa's emissions (excl. LULUCF) between 2000 and 2022.

Sectoral trends

Energy emissions in 2022 accounted for 78 % (excl. LULUCF) (Figure ES1.2) and 86 % (incl. LULUCF) of total emissions for South Africa. Energy emissions declined by 0.2% since 2020. In 2021 emissions increased by 3.5 % but then dropped again in 2022 to pandemic levels. This decrease is due to a 6.5% decrease in emissions from the *Energy Industries* sub-sector, which on average accounts for 67 % of the Energy sector emissions.

IPPU emissions for 2022, accounted 6.4% of South Africa's emissions (excl. LULUCF). The IPPU sector emissions increased by 23.1% since 2020. This was mainly due to the restoration of production in the minerals (26.8%) and metals (26.83%) industry post covid.

Agriculture emissions in 2022 accounted for 12% (excl. LULUCF) and 7% (incl. LULUCF) of total emissions for South Africa. Since 2020 the Agriculture sector emissions have declined by 0.6% and this is due mainly to declining livestock population.

LULUCF sector was a sink of 43 060 Gg CO_2e in 2022. The LULUCF sink grew by a further 17.9% between 2020 and 2022. There was first a decline in 2021 due to increased losses from fires, but this then recovered in 2022 were an increase in the conversion of *Grassland* to *Forest land* produced an increased *Forest land* sink.

Waste sector emissions for 2022 accounted 4.3% (excl. LULUCF) and 4.8% (incl. LULUCF) of the total emissions, with waste sector emissions have increased by 44.1% since 2000.

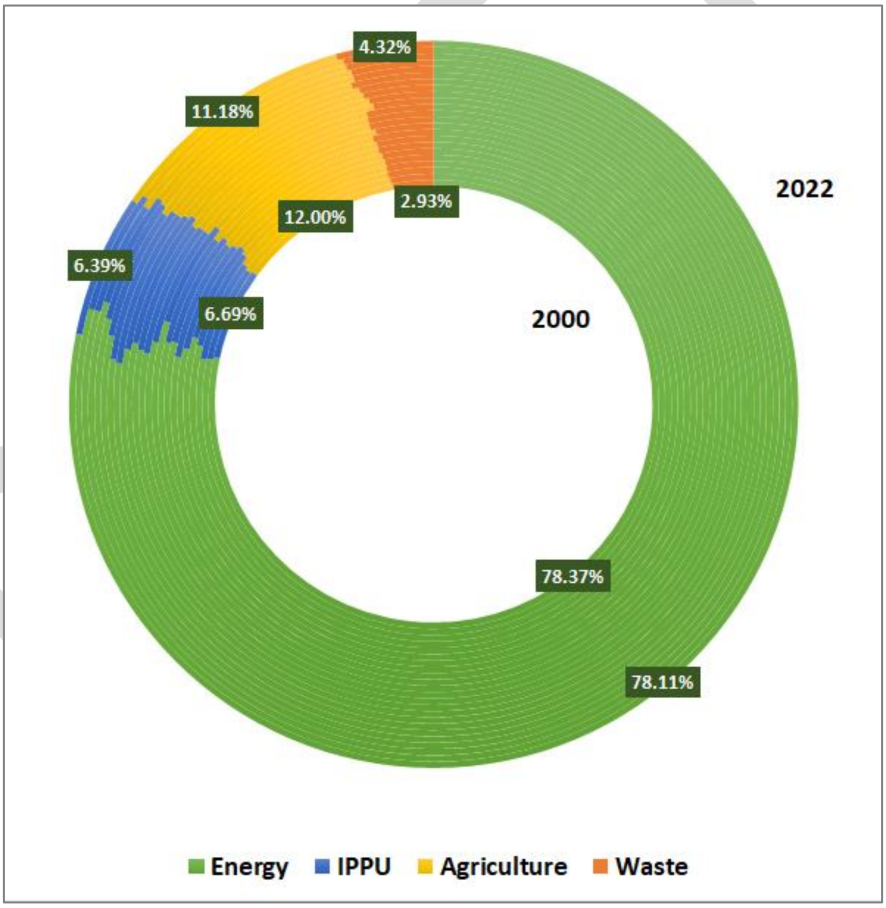

Figure ES 1.2 1: Sector contribution to total emissions (excluding LULUCF) in South Africa between 2000 and 2022.

ES1.4 Improvements and recalculations

Improvements were made to emission estimates from each sector and therefore recalculations were completed for the full time-series. The data shows that the current inventory estimates (excl. LULUCF) are between 0.43% and 5.3% lower than the 2020 inventory estimates, while the estimates (incl. LULUCF) are between 0.23% and 4.94% lower than the 2020 estimates except for 2017 when emission were slightly higher. The Energy sector improvements contribute the most to the reduction in the estimates in this inventory, with an average reduction of 14 294 Gg CO_2e since 2007 compared to the previous inventory.

ES1.5 Key category analysis

A Tier 1 level and trend assessment were conducted, following Approach 1 (IPCC, 2006), on both the emissions including and excluding LULUCF to determine the key categories for South Africa. For the 2000-2022 inventory the level of disaggregation for each sector was updated.

Forest land converted to grassland, *Direct N_2O emissions from managed soils* and *Ferroalloy production* are new to the top 10 key categories. In the previous inventory these categories were in 26th (as *Land converted to grassland*), 16th and 15th place, respectively.

ES1.6 General uncertainty evaluation

Uncertainty analysis is regarded by the IPPC Guidelines as an essential element of a complete and transparent inventory. A trend uncertainty between the base year and 2022, as well as a combined uncertainty of activity data and emission factor uncertainty was determined using an Approach 1. The total uncertainty for the inventory was determined to be between 12.1% and 12.5% including LULUCF, with an uncertainty of 8.9% introduced into the trends.

Excluding LULUCF reduced the overall uncertainty to 5.7%-6.4% with the trend uncertainty dropping to 4.4%.

ES1.7 Quality control and quality assurance

In accordance with IPCC requirements, the national GHG inventory preparation process must include quality control and quality assurance (QC/QA) procedures. For the 2000-2022 National Inventory, quality checks were completed at four different levels, namely (a) inventory data (activity data, EF data, uncertainty, and recalculations), (b) database (data transcriptions and aggregations), (c) metadata (documentation of data, experts and supporting data), and (d) inventory report.

ES1.8 Completeness of the national inventory

The South African GHG emission inventory for the period 2000 – 2022 is not complete, mainly due to the lack of sufficient data. This chapter provides information on the completeness of the inventory in terms activities that are not estimated (NE), included elsewhere (IE) or that is not occurring (NO) within the South African jurisdiction.

ES1.9 Uncertainty analysis

South Africa has conducted uncertainty analysis for the inventory. A trend uncertainty between the base year and 2022, as well as a combined uncertainty of activity data and emission factor uncertainty was determined using an Approach 1. The total uncertainty for the inventory was determined to be between 8.13% and 8.77% including FOLU, with a trend uncertainty of 6.71%. Excluding FOLU reduced the overall uncertainty to be between 6.64% and 7.32%, with the trend uncertainty reduced to 6.21%.

ES1.10 Improvement plan

The main challenge in the compilation of South Africa’s GHG inventory remains the availability of specific-activity and emission factor data. The DFFE is in the process of implementing the National Greenhouse Gas Improvement Programme (GHGIP). The programme consists of a series of sector-specific projects that will result in improvements in activity data, country-specific methodologies and emission factors used in the most significant sectors.

ES.2 Information necessary to track progress made in implementing and achieving National Determined Contributions

ES2.1 Introduction

This chapter in South Africa’s Biennial Transparency Report includes details on national circumstances, institutional arrangements, and mitigation policies related to the NDC. This chapter outlines how various factors, such as government structure, population profile, geography, economy, and climate, influence a country’s ability to implement and achieve its NDC under Article 4 of the Paris Agreement. It emphasizes the importance of effective institutional arrangements for reliable information gathering and processing, which supports decision-making, improves reporting efficiency, and tracks mitigation actions. Furthermore it provides information about key indicators, mitigation and projections of emissions which informs tracking of NDC implementation and achievement of the NDC.

South Africa’s updated NDC, published in 2021, sets specific greenhouse gas emission targets for 2025 and 2030. By 2025, the target is to limit emissions to 398-510 MtCO2e, and by 2030, the target range is 350-420 MtCO2e. The chapter also covers projections of future greenhouse gas emissions and specific indicators to measure progress.

ES2.2 National circumstances and institutional arrangements

South Africa, a constitutional democracy with a three-tiered government system and an independent judiciary, ensures legislative and executive authority at national, provincial, and local levels. The Constitution and relevant laws safeguard citizens' rights to a healthy environment and address climate change, with the Climate Change Act 22 of 2024 enhancing coordination across government levels. The country, bordered by the Atlantic and Indian Oceans, has diverse climates and significant natural resources. Between 2017 and 2020, the population grew by 5.48%, while the GDP declined due to the COVID-19 pandemic. High CO_2 emissions from fossil fuels have prompted a push for green technologies to transition to a low-carbon economy. In 2022, the population was estimated at 62 million, with Gauteng being the most populous province. The COVID-19 pandemic increased mortality rates and decreased life expectancy. South Africa's diverse geography and climate, ranging from Mediterranean to desert, have seen increased extreme weather events like droughts, floods, and fires, impacting agriculture, water security, and causing significant damage and displacement.

ES2.3 Legal arrangements

South Africa's Nationally Determined Contributions (NDC) commitments for 2020-2030, approved by the country's parliament in 2021, aim to limit carbon dioxide equivalent emissions to 398-420 million tonnes, supporting the long-term goal of net zero emissions by 2050. The National Development Plan 2030 focuses on creating a low-carbon economy, with goals that include reducing greenhouse gas (GHG) emissions and implementing zero-emission building standards. The National Climate Change Response Policy aims to build resilience and manage climate impacts, while the Climate Change Act 22 of 2024 provides a regulatory framework for setting emission targets and carbon budgets. The Presidential Climate Commission oversees the just transition to a low-emissions economy, engaging various stakeholders. Additionally, overarching mitigation policies like the National Greenhouse Gas Emission Reporting Regulations and the Carbon Tax Act ensure transparency and incentivize emission reductions.

ES2.4 Measurement Reporting and Verification (MRV)

South Africa is actively implementing and tracking its NDCs under Article 4 of the Paris Agreement through a comprehensive framework managed by the Department of Forestry, Fisheries and the Environment (DFFE). The DFFE coordinates and monitors national environmental policies and compiles National GHG Inventories via the National Greenhouse Gas Information System (NGHGIS). The South African Climate Change Information System (NCCIS) tracks progress towards a low-carbon economy, offering decision support tools and databases for adaptation and mitigation actions. The National Greenhouse Gas Emission Reporting Regulations (NGERs) ensure accurate data collection from various sectors, while the South African Greenhouse Gas Emissions Reporting System (SAGERS) facilitates industry compliance. The Tracking and Evaluation (T&E) Portal within the NCCIS monitors progress towards NDC goals, supported by data from national, provincial, and local systems. Financial data is tracked through a National Climate Finance Support Strategy, and regular communication materials are produced to inform both domestic and international audiences. Sub-national frameworks, supported by external funding, further enhance data collection and integration at provincial levels.

South Africa is implementing and achieving its NDCs under Article 4 of the Paris Agreement through the National Climate Change Response Policy and the Climate Change Act. This involves allocating Sectoral Emissions Targets (SETs) to policy sectors, setting Carbon Budgets, and developing mitigation plans for industry. The verification process for the Carbon Tax regime, administered by the National Treasury and SARS, is also supported. The Department of Forestry, Fisheries and the Environment (DFFE) coordinates the allocation and implementation of SETs with sector departments, provinces, and local governments. The implementation of the Climate Change Act will make these measures legally enforceable. Stakeholder engagement is crucial, with climate-related policies, regulations, and communications undergoing public consultation and commenting processes to ensure transparency and inclusivity.

ES2.5 Description of a Party's nationally determined contribution under Article 4 of the Paris Agreement, including updates

South Africa has set economy-wide goals to reduce GHG emissions, targeting 398-510 million tonnes of CO_2-eq by 2025 and 350-420 million tonnes by 2030, without using reference points or baselines. The NDC is structured into two five-year periods (2021-2025 and 2026-2030) and covers sectors like Energy, IPPU, AFOLU, and Waste, excluding emissions from natural disturbances. While some subcategories and gases like SF6 and NF3 are not included due to data limitations, the NDC aligns with the 2017 National Inventory Report. South Africa also hosts Clean Development Mechanism projects and may engage in cooperative approaches under Article 6 of the Paris Agreement.

ES2.6 Information necessary to track progress made in implementing and achieving South Africa's nationally determined contribution under Article 4 of the Paris Agreement

South Africa tracks progress in implementing and achieving its NDC under Article 4 of the Paris Agreement by monitoring national GH emissions, both excluding and including land use, land-use change, and forestry (LULUCF). National GHG emissions excluding LULUCF encompass emissions from sectors such as energy, industrial processes, agriculture (excluding land-related emissions), and waste, while those including LULUCF also account for emissions and removals from land use changes and forestry activities. In 2021, South Africa's GHG emissions excluding LULUCF were 488.32 Mt CO2-eq, and 478.89 Mt CO2-eq in 2022. Including LULUCF, emissions were 464.96 Mt CO2-eq in 2021 and 435.83 Mt CO2-eq in 2022. These emissions are within the mitigation targets for 2021-2025. South Africa uses IPCC methodologies and global warming potential values to estimate and report emissions, ensuring consistency with its NDC targets. The country's GHG inventory-based method and adherence to international guidelines facilitate accurate tracking and reporting of progress towards its climate goals.

ES2.7 Mitigation policies and measures, actions and plans, related to implementing and achieving a nationally determined contribution under Article 4 of the Paris Agreement

South Africa's energy sector is pivotal in the country's efforts to reduce greenhouse gas (GHG) emissions and promote sustainable development. Key programs such as the 12L tax incentive, Eskom Integrated Demand Management (IDM), and Municipal Energy Efficiency and Demand Side Management (EEDSM) have collectively cut GHG emissions by 5 Mt CO2e annually from 2010 to 2022. Initiatives like the Renewable Energy Independent Power Producer Procurement (REIPPP) and the Natural Gas Fuel Switch programme have further reduced emissions by 16 Mt CO2e, contributing to a total reduction of 21 Mt CO2e, which represents 36% of sector-wide emission reductions.

In the transport sector, the Bus Rapid Transit (BRT) programme and the Transnet Road-to-Rail Programme have reduced GHG emissions by 0.3 Mt CO2e annually from 2010 to 2022. The BRT programme improves urban public transportation, reducing traffic congestion and fuel consumption, while the Road-to-Rail Programme shifts freight transport from road to rail, further lowering emissions.

The Industrial Processes and Product Use (IPPU) sector has seen significant reductions in N2O emissions through advanced technologies and process modifications, contributing to an annual reduction of 1.3 Mt CO2e from 2010 to 2022. These efforts support South Africa's climate goals by lowering the environmental impact of nitric acid production.

In agriculture, conservation agriculture and grassland restoration have reduced emissions by 2.1 Mt CO2e annually from 2010 to 2022. These practices, promoted through various government programs, enhance soil health, water retention, and agricultural productivity.

The forestry sector, primarily through afforestation and forest restoration, has achieved the largest emission reductions, accounting for 54% of the total reductions, or 31 Mt CO2e annually from 2010 to 2022. These actions boost environmental sustainability, biodiversity, and ecosystem health.

Other land use initiatives, including thicket and shrubland restoration, have reduced emissions by 2 Mt CO2e annually from 2010 to 2022. These efforts restore degraded ecosystems, improving their ecological health and functionality.

The National Waste Management Strategy (NWMS) of 2020 has provided a framework for sustainable waste management, reducing GHG emissions by 0.65 Mt CO2e annually from 2010 to 2022 through waste minimization, recycling, composting, and public awareness programs. Municipal Landfill Gas Destruction initiatives have further contributed to reducing emissions by 0.26 Mt CO2e annually by converting landfill gas into energy.

Overall, domestic Policies and Measures (PAMs) have decreased GHG emissions by 11% annually from 2010 to 2022, with significant contributions from land cover, land use, forestry (56%), and energy (36%) sectors. These efforts are crucial for South Africa's transition to a low-carbon, sustainable future

ES2.8 Summary of greenhouse gas emissions and removals

The GHG emissions from 2022 to 2030, both with and without Land Use, Land-Use Change, and Forestry (LULUCF) are reported. Over this period, emissions generally decrease, with notable reductions in 2026, 2029, and especially 2030. Emissions without LULUCF are consistently higher than those with LULUCF, highlighting the significant impact of land use and forestry on mitigating total emissions. The data shows a peak in emissions in 2024, followed by a downward trend, culminating in the lowest emissions in 2030.

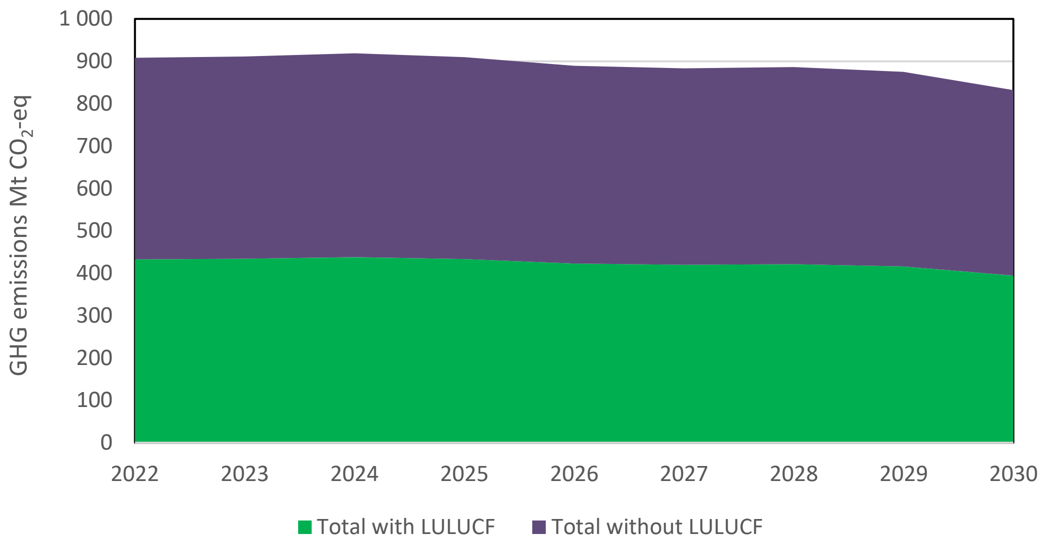

Figure ES.2.7.1: GHG emission projections with and without LULUCF

The GHG emission projections are an output of the DFFE Integrated Climate Change Mitigation Model. The model uses historical data and assumptions to project South Africa's GHG emissions up to 2050. It incorporates various studies and models, including the Mitigation Potential Analysis and the Policies and Measures model, to update historical data and assumptions. The model employs a bottom-up approach, using two linked economic models to estimate emissions and assess socio-economic impacts of mitigation strategies. Additionally, it integrates population projections aligned with the United Nations' data to provide comprehensive insights for policymakers on the economic and environmental implications of different energy pathways.

ES2.10 Application of flexibility provision for reporting

Due to capacity constraints, flexibility is applied in accordance with paragraphs 85, 92, 95, and 102 of the MPGs in this BTR. Consequently, estimates of expected emission reductions from current policies, actions, and measures are not reported, although achieved emission reductions are included. The report provides a 'with measures' projection of all GHG emissions and removals but does not include projections for 'with additional measures' or 'without measures'. While the methodologies, underlying models, assumptions, and parameters used to develop these projections are robustly reported, they are presented in less detail. Additionally, projections on a sectoral basis and by gas are not included.

ES.3 Climate Change Impacts and Adaptation

This chapter on Climate Change Impacts and Adaptation offers a comprehensive overview of South Africa's efforts to respond to the escalating challenges posed by climate change. Although this chapter is not mandatory for reporting in the first Biennial Transparency Report (BTR), South Africa has chosen to include this aspect as adaptation presents a key priority for the country to effectively address the challenges posed by climate change and build resilience in vulnerable communities. The primary objective of the adaptation chapter in the SABTR1 is to report on South Africa's climate change adaptation status quo and to inform progress on the work and knowledge required to support the country's climate change adaptation response. This chapter therefore provides a comprehensive picture of the country's efforts towards climate change response and the progress towards expected outcomes.

The Climate Change Adaptation Chief Directorate within the Department of Forestry, Fisheries, and the Environment (DFFE) plays a pivotal role in leading South Africa's climate change adaptation efforts. It is responsible for developing, coordinating, and implementing national climate adaptation policies, strategies, and plans, ensuring alignment with both national development goals and international climate agreements such as the Paris Agreement. The Chief Directorate facilitates cross-sectoral collaboration among various government departments, research institutions, civil society, and the private sector to promote adaptive capacity and resilience across all levels of government. It also oversees the monitoring and evaluation of adaptation initiatives, ensuring that progress is tracked and reported in accordance with the National Climate Change Adaptation Strategy (NCCAS) and other regulatory frameworks, thereby fostering a coordinated and effective national response to climate change impacts.

South Africa is experiencing significant climate shifts, with temperatures rising at 1.5 times the global average, leading to more frequent and severe extreme weather events, including droughts, floods, and heatwaves. The country is highly vulnerable to these changes, which have profound effects on critical sectors such as agriculture, water resources, health, biodiversity, and infrastructure. The agricultural sector is highly vulnerable to changes in temperature and precipitation patterns, resulting in reduced crop yields, increased pest outbreaks, and livestock productivity losses. Water resources are at risk due to heightened variability in rainfall, more frequent droughts, and declining water quality, threatening supply for human consumption, agriculture, and industry. The health sector faces heightened risks from climate-induced diseases, heat stress, and food and water insecurity, which disproportionately affect vulnerable communities. Biodiversity is threatened by habitat loss, shifting species distributions, and increased frequency of extreme weather events, which disrupt ecosystems and reduce resilience. Infrastructure, including transport, energy, and coastal developments, is increasingly exposed to damage from flooding, storm surges, and sea-level rise, necessitating significant adaptation efforts to safeguard socio-economic stability and development.

South Africa’s adaptation response to sectoral risks and vulnerabilities is anchored in a comprehensive and integrated approach that aligns with the National Climate Change Adaptation Strategy (NCCAS). The country emphasizes cross-sectoral coordination, stakeholder engagement, and community participation to ensure that adaptation actions are inclusive, locally relevant, and effectively implemented across all levels of governance. Acknowledging the crucial role of gender and indigenous knowledge, South Africa’s adaptation framework actively promotes the inclusion of women in decision-making processes and leverages indigenous knowledge systems (IKS) to enhance community-based adaptation. By integrating traditional practices and local knowledge, particularly from marginalized communities, the country aims to develop more culturally appropriate, effective, and sustainable adaptation measures, ensuring that all voices are heard and that the benefits of adaptation are equitably shared. South Africa’s recently enacted Climate Change Act (2024) is a significant legal framework guiding South Africa's transition to a low-carbon, climate-resilient economy. The Act provides mechanisms for both mitigation and adaptation, defining roles for government departments to coordinate climate actions.

South Africa has made significant strides in climate adaptation through a combination of mechanisms, strategies, and policies with clear objectives on adaptation aimed at enhancing resilience across various sectors. However, the country faces challenges such as insufficient financial resources, limited human capacity at local levels, and barriers to coordination across government tiers. Addressing these gaps is essential for the successful implementation of adaptation strategies.

Key barriers to effective adaptation include limited financial resources, insufficient political will, inadequate human capacity, and gaps in coordination across government levels. Addressing these challenges is essential for the successful implementation of adaptation plans.

The establishment of the National Climate Change Information System (NCCIS) marks a critical step in tracking progress on adaptation actions. This system is designed to monitor, evaluate, and report on the effectiveness of adaptation strategies, ensuring transparency and accountability in South Africa’s climate change response.

South Africa has made significant progress in addressing loss and damage from climate change by developing guiding frameworks, fostering cross-institutional collaboration, engaging in stakeholder consultations, and advancing research initiatives. The country has established comprehensive guidelines that outline a systematic approach to collecting data on climate-related disasters, economic losses, social impacts, and environmental degradation. These guidelines leverage inputs from various sources, including the South African Weather Service (SAWS), the National Disaster Management Centre (NDMC), and other relevant agencies, to ensure accurate and robust data collection. This coordinated approach enhances the country's capacity to monitor, evaluate, and respond effectively to the multifaceted impacts of climate change. These efforts, along with active participation in international negotiations, underscore South Africa's commitment to minimizing and addressing loss and damage, while advocating for increased support from the global community to build resilience in vulnerable communities.

This chapter underscores the urgency of advancing South Africa’s adaptation efforts to safeguard its people, ecosystems, and economy. By focusing on sectoral vulnerabilities, strengthening legal frameworks, and enhancing institutional collaboration, the country is working towards building a climate-resilient society. However, sustained financial investment and capacity-building are crucial for the long-term success of these initiatives.

ES.4 Financial, technology development and transfer, and capacity-building support needed and received

The chapter provides an update from the previous Biennial Update Reports (BURs) on financial, capacity and technical support received and needed by South Africa between 1 Jan 2021 and 31 Dec 2022. The chapter presents an analysis of international and domestic climate-related finance flows, as well as non-monetised support, received within the reporting period.

South Africa's national circumstances are described in the context of the climate finance landscape and institutional arrangements relevant to reporting on financial, technology and capacity building support needed and received. Tools and/or assessments to track and report support needed and received including the Climate Finance Landscape Analysis, the Climate Finance Accelerator, the Climate Budget Tagging (CBT) system, the Green Finance Taxonomy, and the JET Projects' Register.

The institutional arrangements relevant to reporting on financial, technology and capacity support needed and received are described in terms of data providers and the flow of information from various directorates within the DFFE who are responsible for outputs to the United Nations Framework Convention on Climate Change (UNFCCC), viz. National Communications, Biennial Transparency Reports and Nationally Determined Contributions.

South Africa's climate finance needs are informed by the revised targets proposed in South Africa's revised NDC lodged with the UNFCCC in 2021, as well as on the Just Transition Investment Plan (JET IP) (2023-2027). Investments are needed in three priority sectors: electricity, New Energy Vehicles (NEVs), and Green Hydrogen (GH_2). More specifically, investment is needed in our electricity transmission and distribution networks and dramatically expanding renewable energy generation, as well as investment in local production of green hydrogen and electric vehicles, and investing in local economies to develop skills and enable economic diversification. Further investments are needed in two cross-cutting areas: skills development and municipalities.

The international financial support received/committed and domestic funds received/committed through government grants and loans were provided in Section 4.4. Over the reporting period for 2021 and 2022, South Africa received in excess of USD$ 5149 million in bilateral support and US$ 25.8 million from multilateral sources that support or benefit climate change actions in the country. Aggregated domestic climate finance across various categories was provided in the domestic support received section in the Energy, AFOLU, Climate and Resilience and Waste categories.

Technology support needed and received from international donor funding sources are described in terms of the JET. Capacity building support needed is outlined in terms of capacity needs for Climate Budget Tagging; for the Just Energy Transition (JET) Skills Implementation Plan, and for gender-climate mainstreaming. Capacity building support received from the developed countries is also provided. South Africa received multilateral financial support from the Global Environment Facility (GEF) as part of the Capacity Building Initiative for Transparency (CBIT) Project for South Africa, and this included support for the compilation of the SABTR1. South Africa also received multilateral financial support from the GEF as part of GEF Expedited Enabling Activity (EEA) for South Africa for the preparation of its initial Biennial Transparency Report to the UNFCCC (current report).

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List of Abbreviations

Abbreviation	Name
ADZs	Aquaculture Development Zones
AFOLU	Agriculture, Forestry and Other Land Use
BMA	Biodiversity Management Agreements
BMP	Biodiversity Management Plan
BTR	Biennial Transparency Report
BUR	Biennial Update Reports
CBIT	Capacity Building Initiative for Transparency
CBT	Climate Budget Tagging
CCAMP	Climate Change Adaptation and Mitigation Plan
CCAQM	Climate Change Air Quality Management
CCRS	Climate Change Response (Adaptation and Mitigation) Strategy
CCD&IM	Directorate: Climate Change Development and International Mechanisms
CDD	Consecutive dry days
CFA	Climate Finance Accelerator
CH_4	Methane
CHASA	Climate and Health Alliance of South Africa
CHBS	Climate-Based Health Services Project
CMIP6	Coupled Model Intercomparison Project Phase 6
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
COL	Cut-off-low
COP	Conference of the Parties
CRF	Concentration Response Function
CRU	Climatic Research Unit
CRV	Climate Risk and Vulnerability
CSA	Climate Smart Agriculture
CSIR	Council for Scientific and Industrial Research
CSP	Country Strategy Paper
CWD	Consecutive wet days
DAFF	Department of Agriculture, Forestry and Fisheries
DALRRD	Department of Agriculture, Land Reform and Rural Development

Abbreviation	Name
DARDLEA	Department of Agriculture, Rural Development, Land and Environmental Affairs
DEA	Department of Environmental Affairs
DFFE	Department of Forestry, Fisheries and Environment
DFFE-ACF	DFFE Adaptive Capacity Facility
DMRE	Department of Mineral Resources and Energy
DoE	Department of Energy
DOH	Department of Health
DPME	Department of Planning, Monitoring and Evaluation in the Presidency
DSTI	Department of Science, Technology, and Innovation
DTI	Department of Trade and Industry
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EbA	Ecosystem-Based Adaptation
EF	Emission factor
ENSO	El Niño–Southern Oscillation
EPWP	Expanded Public Works Programme
FAW	Fall armyworm
F-gases	Fluorinated gases: e.g., HFC, PFC, SF_6 and NF_3
FOLU	Forestry and Other Land Use
FSA	Forestry South Africa
GAP	Gender Action Plan
GBF	Global Biodiversity Framework
GCF	Green Climate Fund
GDP	Gross domestic product
GEF	Global Environment Facility
GFT	Green Finance Taxonomy
Gg	Gigagram
GHG	Greenhouse gas
GHS	General Household Survey
GIS	Geographic Information Systems
GPG	Good Practice Guidance
GWLs	global warming levels
GWP	Global warming potential
HFC	Hydrofluorocarbons

Abbreviation	Name
HFCT	Hydrogen fuel-cell technologies
HWP	Harvested wood products
ICAT	Initiative for Climate Action Transparency
IDP	Integrated Development Plans
IKS	Indigenous Knowledge Systems
IPCC	Intergovernmental Panel on Climate Change
IPG	International Partner Group
IPPU	Industrial Processes and Product Use
IRP	Integrated Resource Management Plan
ISIMIP	Inter-Sectoral Impact Model Intercomparison Project
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resource Management
JET	Just Energy Transition
JET IP	Just Energy Transition Implementation Plan
JETP	Just Energy Transition Partnership
JET PMU	Just Energy Transition Project Management Office
KCA	Key category analysis
L&D	Loss and Damage
LC	Land cover
LEDS	Low Emissions Development Strategy
LPG	Liquefied petroleum gas
LULUCF	Land Use, Land Use Change and Forestry
M&E	Monitoring and Evaluation
MH-EWS	Multi-hazard Early Warning System
MSPF	Marine Spatial Planning Framework
MTSF	Medium-Term Strategic Framework
MURP	Municipal Risk Pooling
MWH	Megawatt hours
MWTP	Municipal wastewater treatment plant
N_2O	Nitrous oxide
NAEIS	National Atmospheric Emissions Inventory System
NAP	National Adaptation Plan
NBSAP	National Biodiversity Strategy and Action Plan
NCCARA	National Climate Change Adaptation Research Agenda
NCCAS	National Climate Change Adaptation Strategy

Abbreviation	Name
NCCHAP	National Climate Change and Health Adaptation Plan
NCCIS	National Climate Change Information System
NCCMR&E Framework	National Climate Change Monitoring and Evaluation System Framework
NCCRD	National Climate Change Response Database
NCCRP	National Climate Change Response Policy
NCCRS	National Climate Change Response Strategy
NCV	Net calorific value
NDC	Nationally Determined Contributions
NDMC	National Disaster Management Centre
NDMF	National Disaster Management Framework
NDP	National Development Plan
NE	Not estimated
NEMBA	National Environmental Management: Biodiversity Act
NEV	New Energy Vehicles
NFCS	National Framework for Climate Services
NGHGIS	National Greenhouse Gas Inventory System
NICD	National Institute for Communicable Diseases
NMVOC	Non-methane volatile organic compound
NO	Not occurring
NOx	Oxides of nitrogen
NQF	National Qualifications Framework
NT	National Treasury
NTCSA	National Terrestrial Carbon Sinks Assessment
NTCSP	National Treasury Cities Support Programme
ODA	Official Development Assistance
OECM	Other Effective Area-Based Conservation Measures
PCC	Presidential Climate Commission
PFC	Perfluorocarbons
PGM	Platinum group metals
QA/QC	Quality assurance/quality control
r20mm	count of extreme rainfall days which is used for events that potentially lead to floods
REIPPPP	Renewable Energy Independent Power Producer Procurement Program
RSA	Republic of South Africa
SAAM	South African Automotive Masterplan
SAAQIS	South African Air Quality Information System

Abbreviation	Name
SADC	Southern African Development Community
SAGERS	South African GHG Emissions Reporting System
SAMA	South African Medical Association
SAMRC	South African Medical Research Council
SANBI	South African National Biodiversity Institute
SAPIA	South African Petroleum Industry Association
SAR	Second Assessment Report
SAREM	South African Renewable Energy Master Plan
SARVA	South African Risk and Vulnerability Atlas
SAWS	South African Weather Service
SDG	Sustainable Development Goals
SF_6	Sulphur hexafluoride
SOC	Soil organic carbon
SPEI	Standardized precipitation index
SPLUMA	Spatial Land Use Management Act
SSPs	Shared Socioeconomic Pathways
Stats SA	Statistics South Africa
SUDS	Sustainable Urban Drainage Systems
SWID	Severe Weather Impact Database
TAR	Third Assessment Report (IPCC)
TIA	Technology Innovation Agency
TM	Tier method
TNA	Technology Needs Assessment
Txx	Maximum daytime temperature
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
Upper bound poverty line	UBPL
WCWDM	Water Conservation and Water Demand Management
WCWDMS	Water Conservation and Water Demand Management Strategy
WfW	Working for Water
WMO	World Meteorological Organisation

1 National inventory report of anthropogenic emissions by sources and removals by sinks of greenhouse gases

1.1 National GHG Inventory Summary

1.1.1 Introduction

This chapter presents a summary of the National Greenhouse Gas (GHG) Inventory for South Africa prepared for the year 2022. It also reports on the GHG trends for the period 2000 to 2022. The inventory was compiled in accordance with the Intergovernmental Panel on Climate Change (IPCC) 2006 guidelines for Inventories, IPCC Good Practice Guidance (GPG) (IPCC, 2000; IPCC, 2003; IPCC, 2014) and the 2019 Refinement to the 2006 IPCC Guidelines (IPCC, 2019).

The 2000-2022 National GHG Inventory for South Africa covers sources of GHG emissions and removals by sinks, resulting from human (anthropogenic) activities for the major GHGs: carbon dioxide (CO_2), methane (CH_4), nitrogen dioxide (N_2O), perfluorocarbons (PFCs) and hydrofluorocarbons (HFCs). The indirect GHGs: carbon monoxide (CO), nitrous oxides (NO_X) and non-methane volatile organic compounds (NMVOCs) are also included for biomass burning, with some information on sulphur hexafluoride (SF6) also included. The gases are reported under five sectors: *Energy*; *Industrial Processes and Product Use* (*IPPU)*; *Agriculture, Land Use, Land Use Change and Forestry (LULUCF)* and *Waste*.

1.2 National circumstances

1.2.1 Background information on GHG inventories

The Republic of South Africa ratified the UNFCCC in August 1997. South Africa submitted its first national GHG inventory in 1998 (Van der Merwe & Scholes, 1998) using 1990 data, and was subsequently published the 2004 national GHG inventory using data for 1994. These inventories were developed using the 1996 IPCC Guidelines for National Greenhouse Gas Inventories. The national GHG inventory that followed for 2000 (DEAT, 2009) used the 2006 IPCC Guidelines (IPCC, 2006). Subsequently, the 2014 the GHG inventory for the years 2000 to 2010 (DEA, 2014), an update for 2011 and 2012 in 2017 (DEA, 2017), 2013 to 2015 in 2019 (DEA, 2019), 2017 in 2021 (DFFE, 2021), and for 2018, 2019 and 2020 in 2023 (DFFE, 2023) were compiled using the 2006 IPCC guidelines.

1.2.2 Global warming potentials

To allow for the integrated effect of emissions of the various gases to be compared, GHGs are converted to carbon dioxide equivalents (CO_2e). CO_2e using the 100-year global warming potentials (GWPs) from the 2014 IPCC Fifth Assessment Report (AR5). These GWPs (

Table 1.1Table 1.3) are in accordance with the Modalities, Procedures, and Guidelines (MPGs) for transparency framework for action and support, referred to in Article 13 of the Paris Agreement, used to comply with international reporting obligations under the UNFCCC.

Table 1.1: Global warming potential (GWP) of greenhouse gases used in 2000-2022 National GHG inventory and taken from AR5 (IPCC, 2014b).

Greenhouse gas	Chemical formula	AR5 GWP
Carbon dioxide	CO_2	1
Methane	CH_4	28
Nitrous oxide	N_2O	265
Hydrofluorocarbons (HFCs)		
HFC-23	CHF_3	12 400
HFC-32	CH_2F_2	677
HFC-125	CHF_2CF_3	3170
HFC-134a	CH_2FCF_3	1300
HFC-143a	CF_3CH_3	4 800
HFC-227ea	C_3HF_7	3350
HFC-365mfc	$C_4H_5F_5$	804
HFC-152a	CH_3CHF_2	138
Perfluorocarbons (PFCs)		
PFC-14	CF_4	6 630
PF-116	C_2F_6	11 100

In South Africa's National GHG Inventories prior to the 2000 – 2020 inventory were prepared using the IPCC Second Assessment Report (AR2) (IPCC, 1996) GWPs, whereas for the 2000-2022 National inventory the AR5 values as shown in

Table 1.1 were used.

1.3 Institutional arrangements

1.3.1 National Entity

In South Africa the Department of Forestry, Fisheries and the Environment (DFFE) is the central co-ordinating and policy-making authority with respect to environmental conservation. The work of the DFFE is underpinned by the Constitution of the Republic of South Africa (RSA) and all other relevant legislation and policies applicable to government to address environmental management, including climate change. The DFFE is mandated by the Air Quality Act (Act 39 of 2004) (RSA, 2004) to formulate, co-ordinate and monitor national environmental information, policies, programmes and legislation.

The DFFE as the lead climate institution is responsible for co-ordination and management of all climate change-related information, such as mitigation, adaption, monitoring and evaluation programmes, including the compilation and update of National GHG Inventories. The Climate Change and Air Quality Chief Directorate is responsible for the management and co-ordination of GHG inventories at the DFFE (Figure 1.1).

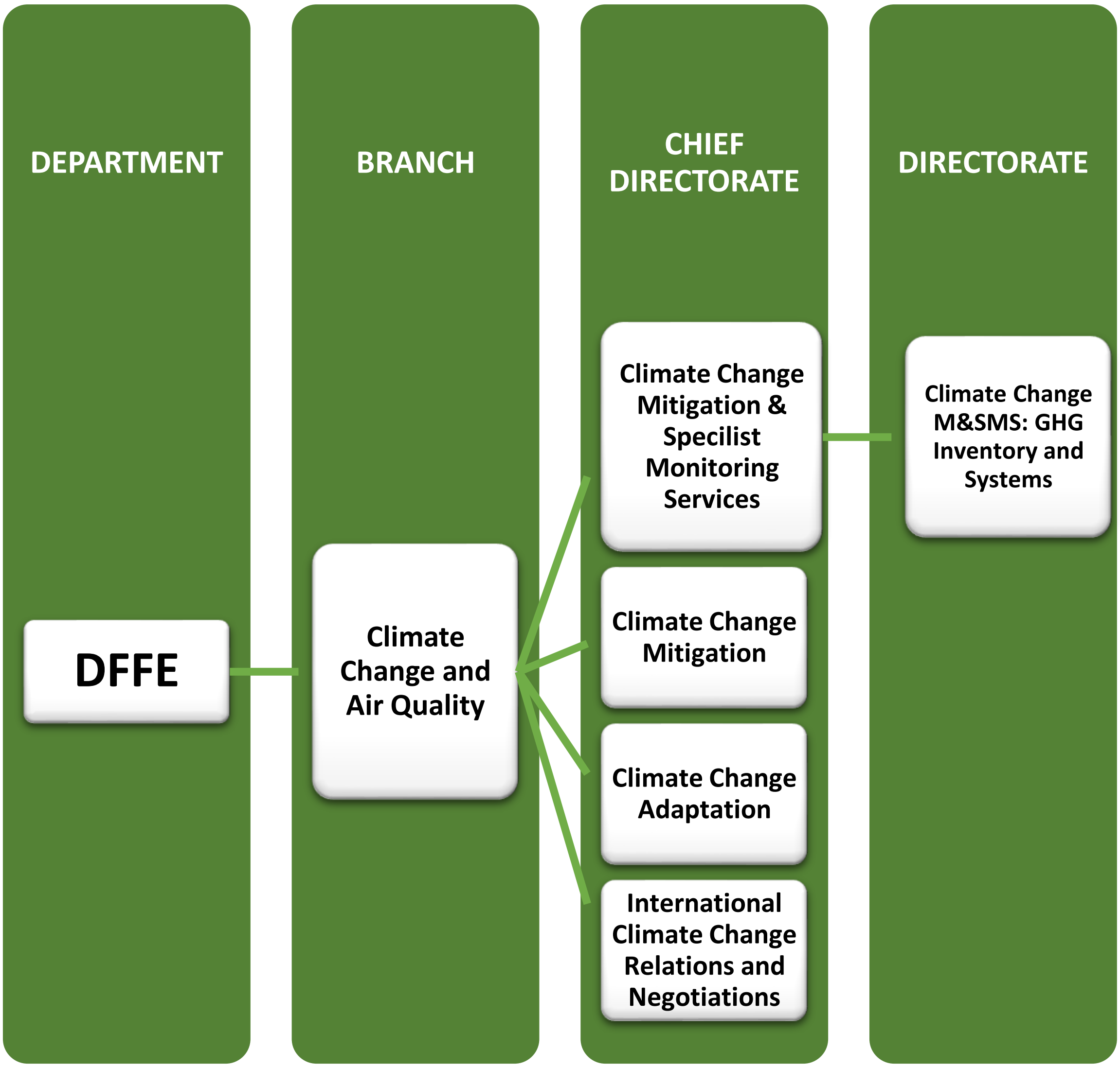

Figure 1.1: Organogram showing where the GHG Inventory compilation occurs within DFFE.

1.3.2 Legal Arrangements

The DFFE takes a lead role in the compilation, implementation and reporting of the national GHG inventories, whilst other relevant agencies and ministries play supportive roles in terms of data provision across relevant sectors. There are no formal agreements between the government departments for the provision of this data.

The National Greenhouse Gas Emission Reporting Regulations (NGERs) (DEA, 2017a), under Section 53(a), (o) and (p) read with section 12 of the National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004), in the Government Gazette of the 3rd April 2017, supports the collection of data for the energy and industrial sectors on a continuous basis in support of the maintaining the National GHG inventory, meeting UNFCCC reporting obligations and informing the formulation and implementation of legislation and policy.

The South African Greenhouse Gas Emissions Reporting System (SAGERS) which is the GHG module of the National Atmospheric Emissions Inventory System (NAEIS) further helps to facilitate the process of enabling Industry to meet its GHG reporting requirements in a web-based secure environment and facilitates the data collection process for energy related activities and IPPU.

The inventory compilation process (Figure 1.2) is co-ordinated through a central web-based inventory management system (National GHG Information Management System (NGHGIS)).

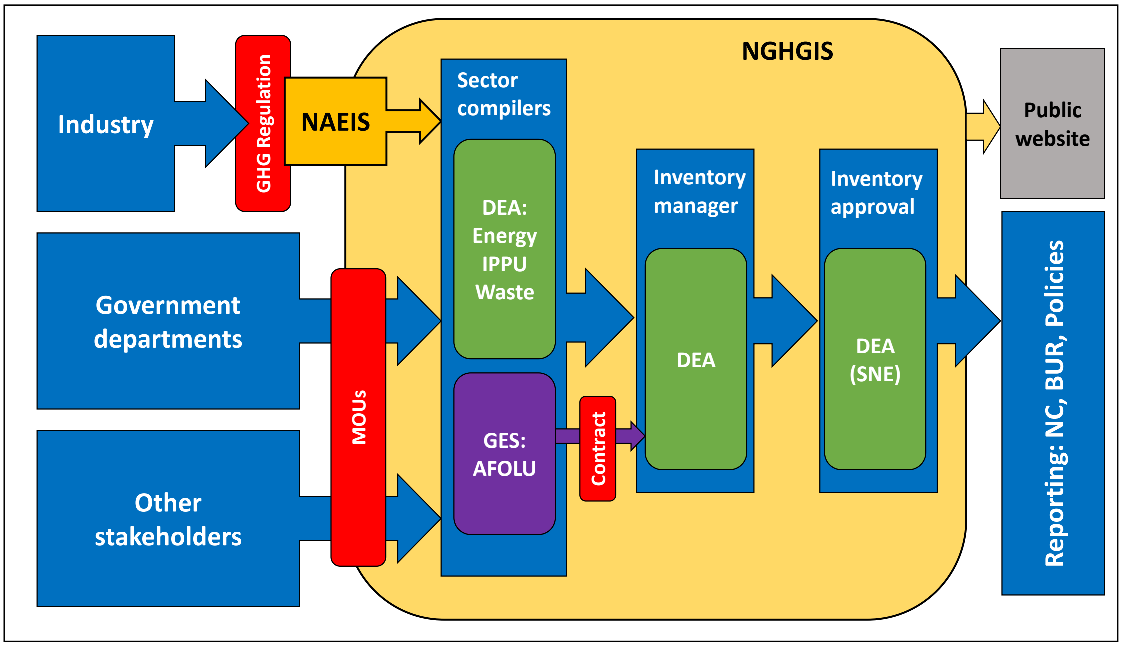

Figure 1.2: The inventory compilation process in South Africa.

1.4 Inventory management and inventory preparations

1.4.1 Inventory management

The management and coordination of the inventory programme, as well as compilation, publication and submission of the inventory are carried out by the Single National Entity (being the DFFE) in a centralised manner. The DFFE is currently responsible for collecting data, compiling and Quality Control (QC) of the Energy, IPPU, Agriculture and Waste sector inventories, while the LULUCF sector is compiled (in collaboration with DFFE) by external consultants (Gondwana Environmental Solutions (GES)) who are appointed via a formal project-based contract with the UNDP as part of the Capacity Building Initiative for Transparency (CBIT) project of South Africa. DFFE assists with the QC of the LULUCF sector. DFFE is also responsible for combining and compiling the overall inventory and compiling the draft National Inventory Report.

1.4.2 Inventory preparation

The stages and activities undertaken in the inventory update and improvement process are shown in Figure 1.3. The process for the 2000-2022 National Inventory Report, began with a planning phase that included the setting of timelines and the preparation of templates for the inventory compilation. This was followed by the preparation phase. The collection phase was dedicated to data collection and preliminary processing, such as data cleansing, data checks and preliminary formatting for further use. The writing phase focussed on the drafting of the inventory report and QC of the draft was completed. The draft document was then subjected to public commenting process. During the finalization phase the archives were prepared and final Report approvals were obtained before being submitted to UNFCCC.

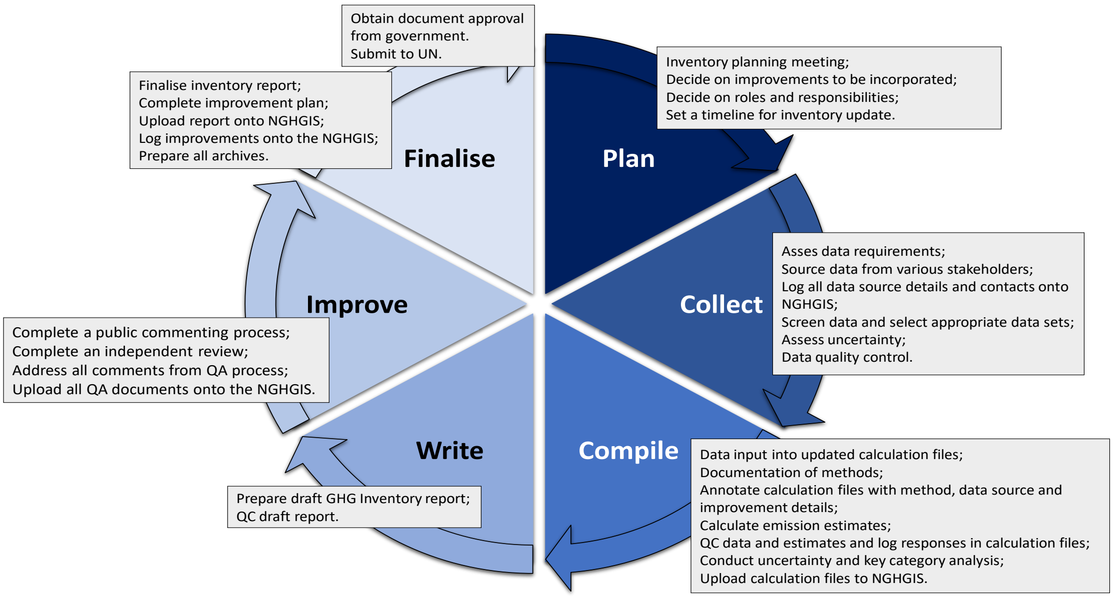

Figure 1.3: Overview of the phases of the GHG inventory compilation and improvement process undertaken for South Africa's 2020 GHG inventory.

1.4.3 Data collection, storage and archiving

1.4.3.1 Data collection

Data collection and documentation for the compilation of the GHG inventory takes place under the responsibility of the relevant experts. Three different processes are used to collect data for South Africa's inventory. The first is by obtaining data from government departments, institutes, companies, and organisations through an informal process, i.e. where data is obtained without any formal data collection agreements. The second is through the evaluation of publicly available data, official statistics, association statistics, studies, periodicals and third-party research projects. Most of the inventory data is collected using these two approaches, but for industry, South Africa has started to move towards a more formalised data collection system.

The NAEIS is an online reporting platform for air quality and GHG emissions from companies to manage the mandatory reporting of GHG emissions. Emissions information including activity data from the NAEIS serves as input data during the national inventory compilation process. DFFE has modified the NAEIS to meet the requirements of the NGERs (DEA, 2017a). This component of the portal, the SAGERS, serves as a tool for the implementation of the online registration and reporting by industry in fulfilment of mandatory NGERs. The key benefit of the portal is that it will enhance the data collection process for the inventory, therefore improving the quality of the national GHG inventories consistent with the requisite principles of completeness, consistency, accuracy, comparability, and transparency.

1.4.3.2 Data preparation and emission calculations

The process of data preparation and emissions calculation comprises the following steps:

a. Data entry

- Data preparation (model formation, disaggregation, aggregation)
- Calculation of emissions
- Preparation of report sections (texts) and
- Approval by the relevant experts.

Report texts are prepared along with the time series for activity data, emission factors, uncertainties, and emissions. As a result, the term "data" is understood in a broad sense. In addition to number data, time series, etc., it also includes contextual information such as the sources for time series, and descriptions of calculation methods, and it also refers to preparation of report sections for the NIR and documentation of recalculations.

After all checks have been carried out, and the relevant parties have been consulted where necessary, the emissions are calculated in excel by each sector lead based on the following principle:

activity data * emission factor = emission

As much of the data as possible is included in the calculation files, but where larger data sets are referred to these are stored in the NGHGIS.

1.4.3.3 Data storage and archiving

The NGHGIS for South Africa assists in managing and storing the inventory related documents and processes through keeping records of the following:

- Stakeholder list with full contact details and responsibilities

- List of input datasets which are linked to the stakeholder list
- QA/QC plan
- QA/QC checks
- QA/QC logs which will provide details of all QA/QC activities
- All method statements
- IPCC categories and their links to the relevant method statements together with details of the type of method (Tier 1, 2 or 3) and emission factors (default or country-specific) applied
- Calculation and supporting files
- Key references
- Key categories; and
- All inventory reports.

1.5 Brief description of methods and data

The methods used for the individual categories are outlined in the sector overview sections in each of the sector chapters of the National Inventory Report (DFFE, 2024). In addition, detailed descriptions are provided in the relevant category chapters. A distinction is made between calculations made with country-specific ("CS") methods and calculations made, in the various categories, with IPCC calculation methods of varying degrees of detail ("Tiers"). Similarly for the emission factors. The way a calculation is assigned to the various IPCC methods depends on the pertinent category's share (expressed as equivalent emissions) of total emissions and this determined via the key category analysis.

In terms of data, for the Energy Sector, Energy balance data is obtained from the Department of Mineral Resources and Energy (DMRE), whereas petroleum data is collected from Petroleum companies (e.g. Petro SA and Sasol) Annual reports of SAPIA and Transnet. Electricity data is obtained from the grid supplier, Eskom. There are currently no formal processes in place for requesting or obtaining data from DMRE. SAGERS, through the GHG Reporting Programme is used for data from major companies.

For the IPPU sector the SAGERs system is used to obtain the data required. The DFFE waste branch supplied the data for HFC and PFC, though no formal data collection process is in place for this.

Agricultural data is primarily obtained from the Department of Agriculture, Land Reform and Rural development (DALRRD). Fertiliser and liming data are sourced from South African Revenue Service (SARS), DMRE and Fertilizer Association of South Africa (FertASA). Small amounts of crop statistics data are obtained from Statistics SA. There are no formal data collection processes in place for all the agriculture data.

Data for the LULUCF sector sub-categories is obtained from various with the DFFE employing consultants on, a project-by-project basis, to process the satellite imagery to generate land cover datasets that are used to determine land cover change for the LULUCF sector.

For all the other land, such as carbon stock data and fuel wood removals data there are no formal data collection processes in place. Data is obtained from available government reports, agricultural association reports, statistical databases and scientific literature. Forestry SA supplies Plantation data and DALRRD supply cropland data. The MODIS burnt area product which is processed by Gondwana Environmental Solutions is used for the burnt area data. The SAGERS system is used plantation data.

Waste data is collected from various data reports, statistics and global data sets. The main data providers for the Waste sector are Statistics SA, DFFE, Department of Water and Sanitation (DWS) and UN. Currently no formal data collection processes are place, though it is anticipated that it may be possible, for future inventories, to collect some of the Waste data through the SAGERS system.

1.6 Quality assurance, quality control and verification plans and procedures

Following the preparation of data, report sections and QC/QA checklists by the responsible experts, these materials are transmitted to the Single National Entity where it is reviewed by category-specific specialists at the Single National Entity. The results of this review are then provided to the sector lead experts to revise and finalise.

The compilation of the GHG inventory was guided by the inventory quality principles as defined in 2006 IPCC Guidelines (IPCC, 2006). As part of the NGHGIS, South Africa developed a formal quality assurance/quality control plan (see Appendix 1.A of 2015 NIR (DEA, 2019)) which provides a list of QC procedures that are to be undertaken during the preparation of the inventory.

The QC procedures (Figure 1.4) are performed by the experts during inventory calculation and compilation. QC measures are aimed at the attainment of the quality objectives. The QC procedures comply with the IPCC Good Practice Guidance and the 2006 IPCC Guidelines. General inventory QC checks include routine checks of the integrity, correctness and completeness of data, identification of errors and deficiencies and documentation and archiving of inventory data and quality control actions.

In addition to general QC checks, category-specific QC checks including technical reviews of the source categories, activity data, emission factors and methods are applied on a case-by-case basis focusing on key categories and on categories where significant methodological and data revisions have taken place.

The general quality checks were used routinely throughout the inventory compilation process. Although general QC procedures are designed to be implemented for all categories and on a routine basis, it is not always necessary or possible to check all aspects of inventory input data, parameters, and calculations every year. Checks are then performed on selected sets of data and processes. A representative sample of data and calculations from every category may be subjected to general QC procedures each year.

Several workshops and training sessions are also held during the preparation of the inventory. A process of public review is also undertaken. The expert and public reviews each present opportunity to uncover technical issues related to the application of methodologies, selection of activity data, or the development and choice of emission factors. Emission and activity data are verified by comparing them with other available data compiled independently of the GHG inventory system where available.

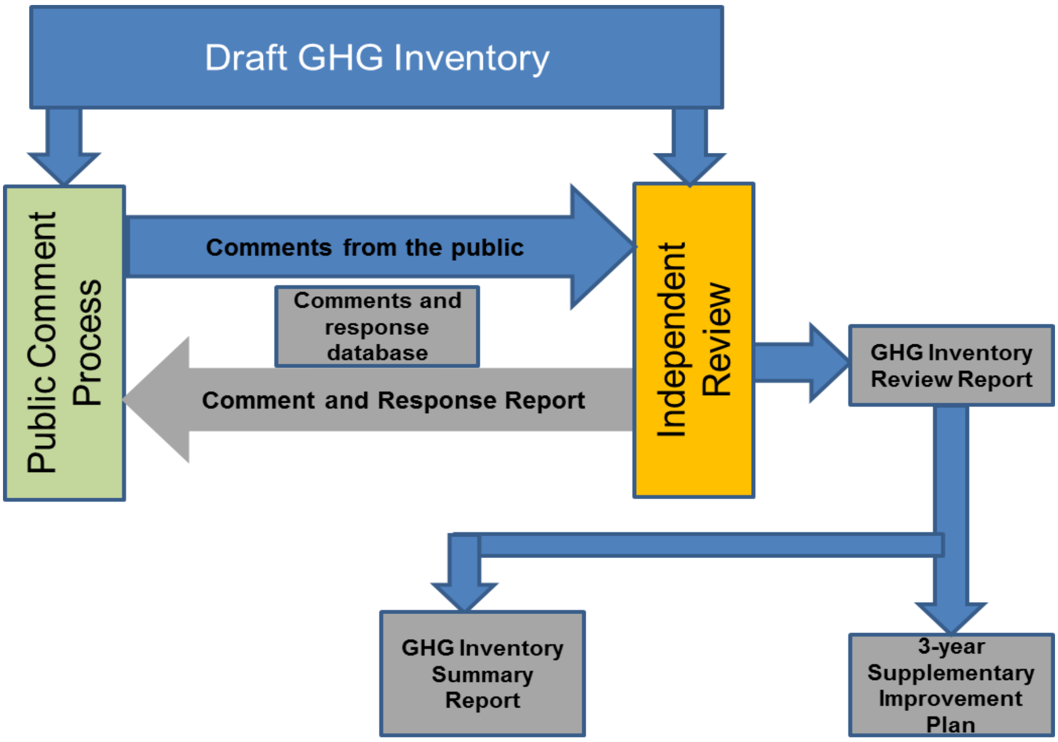

Figure 1.4: The quality assurance review process for the 2000 – 2022 inventory.

In terms of verification, emission and activity data are verified by comparing them with other available data compiled independently of the GHG inventory system where available. These include national and international statistics, measurement and research projects and programmes initiated to support the inventory system, or for other purposes, but producing information relevant to the inventory preparation.

1.7 Key Category analysis

A key category is one that is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory of GHG's in terms of the absolute level of emissions and removals, the trend in emissions and removals, or uncertainty in emissions or removals. This includes both source and sink categories.

A Tier 1 level and trend assessment were conducted, following Approach 1 (IPCC, 2006), on both the emissions including and excluding LULUCF to determine the key categories for South Africa. For the 2000-2022 inventory the level of disaggregation for each sector was updated and the key categories were then ranked according to their combined contribution to the level and trend assessments. In the previous inventory there were 58 key categories, while in this inventory there are 53 with the top-30 shown in *Forest land converted to grassland*, *Direct N_2O emissions from managed soils* and *Ferroalloy production* are new to the top 10 key categories. In the previous inventory these categories were in 26th (as *Land converted to grassland*), 16th and 15th place, respectively.

Table 1.2: Key categories for `South Africa for 2022 (including LULUCF) and their ranking.

Rank	IPCC code	IPCC Category	GHG#	Criteria
1	4.A.2.b	Grassland converted to forest land – all pools	CO_2	L,T
2	1.A.3.b	Road Transportation – Liquid Fuels	CO_2	L,T
3	4.A.1.a	Forest land remaining forest land – biomass	CO_2	L,T
4	1.A.1	Energy Industries – Solid Fuels	CO_2	L,T
5	3.D.1	Direct N_2O Emissions From Managed Soils	N_2O	L
6	4.C.1.a	Grassland remaining Grassland – biomass	CO_2	L,T
7	4.F.2.c	Grassland converted to other land – all pools	CO_2	L,T
8	1.A.5	Other – Solid Fuels	CO_2	L,T
9	2.C.2	Ferroalloys Production	C	L
10	1.B.3	Other emissions from energy production	CO_2	L,T
11	1.A.4	Other Sectors – Liquid Fuels	CO_2	L,T

Rank	IPCC code	IPCC Category	GHG#	Criteria
12	3.A.1.a.ii	Non-dairy Cattle	CH_4	L,T
13	4.G	Harvested Wood Products	CO_2	T
14	5.D	Wastewater Treatment and Discharge – Industrial	CH_4	L
15	1.A.3.a	Domestic Aviation	CO_2	T
16	1.A.1	Energy Industries – Gaseous Fuels	CO_2	T
17	1.A.5	Other – Liquid Fuels	CO_2	T
18	1.A.4	Other Sectors – Solid Fuels	CO_2	L,T
19	2.C.1	Iron and Steel Production	CO_2	L,T
20	3.A.1.a.i	Dairy Cattle	CH_4	L
21	4.A.1.b	Forest land remaining forest land – dead organic matter	CO_2	T
22	5.A	Solid Waste Disposal	CH_4	L,T
23	1.B.3	Other emissions from energy production	CH_4	L
24	2.B.2	Nitric Acid Production	N_2O	T
25	2.C.3	Aluminium Production	F-gases	T
26	1.A.2	Manufacturing Industries and Construction – Gaseous Fuels	CH_4	L,T
27	4.C.2.a	Forest land converted to Grassland – all pools	CO_2	L,T
28	1.B.2	Oil and Natural Gas	CO_2	T
29	4(V)	Biomass Burning	CH_4	L
30	4.B.2.b	Grassland converted to Cropland – all pools	CO_2	L

#C=Confidential

1.8 Uncertainty assessment

1.8.1 Procedures for uncertainty determination

Uncertainty is inherent within any kind of estimation and arises from the limitations of the measuring instruments, sampling processes and model complexities and assumptions. The IPCC (2006) recognises that managing these uncertainties, and reducing them over time, is an important element of inventory preparation and development. Chapter 3 of the 2006 IPCC Guidelines (IPCC, 2006) describes the methodology for estimating and reporting uncertainties associated with annual estimates of emissions and removals. There are two methods for determining uncertainty:

- Tier 1 methodology which combines the uncertainties in activity rates and emission factors for each source category and GHG in a simple way; and
- Tier 2 methodology which is generally the same as Tier 1; however, it is taken a step further by considering the distribution function for each uncertainty, and then carries out an aggregation using the Monte Carlo simulation.

As South Africa still lacks data in terms of country specific uncertainty for all sectors, the simple propagation of error (Approach 1) method was used to determine the uncertainty in this inventory. A trend uncertainty between the base year (2000) and 2022 was determined, as well as a combined uncertainty of activity data and emission factor uncertainty. As more uncertainty data becomes available it will be incorporated into the uncertainty assessment. It is recognised that there is a general need to build capacity and develop projects to assess the uncertainty in each sector.

1.8.2 Uncertainty assessment results

Emission estimate uncertainties typically are low for CO_2 from energy consumption as well as from some industrial process emissions. Uncertainty surrounding estimates of emissions are higher for LULUCF and synthetic gases.

The total uncertainty for the inventory including LULUCF was determined to be between 12.1% and 12.5%, with a trend uncertainty of 8.9%. This is an increase on the uncertainty in the last inventory (8.7%), however there were a few new categories in this inventory and a more detailed uncertainty assessment for Forest lands have been included. This led to an increase in uncertainty on the activity data (mostly due to the increased variability in the land change maps), but a reduction in the emission factor uncertainty. Excluding LULUCF reduces the overall uncertainty to 5.7%-6.4%, which is a reduction of the uncertainty from the last inventory.

The Energy sector uncertainty was reduced slightly (by 5% on the upper limit) compared to the previous inventory. The IPPU trend uncertainty increased by 32% compared to the last inventory. The IPPU sector did introduce some new categories in 2021 and 2022 and update some of the uncertainty estimates to be based on country specific data rather than defaults so these changes could contribute to the uncertainty change. The Agriculture sector uncertainty reduced for both the overall uncertainty and trend uncertainty. The uncertainty data did not really change but the emission estimates did, and there was also reallocation of some categories between Agriculture and LULUCF to align with the ETF CRT reporting.

LULUCF uncertainty increased by about 30% compared to the previous inventory uncertainty analysis. Part of this change was due to the introduction of new land change maps; however additional changes were made due to a more in depth analysis of the uncertainty data rather then it being an actual change in uncertainty. The uncertainty data is one aspect of the inventory, which is being improved, so it is likely there will be further changes in the next inventory. Waste sector uncertainty was reduced, but this is likely due to the reduction in the emissions in this sector due to improvements.

1.9 Assessment of completeness

The South African GHG emission inventory for the period 2000 – 2022 is not complete, mainly due to the lack of sufficient data. Table 1.3 provides information on the completeness of the inventory. It shows which activities are not estimated (NE), included elsewhere (IE) or that is not occurring (NO) within the South African jurisdiction.

Table 1.3: Activities in the 2022 inventory which are not estimated (NE), included elsewhere (IE) or Not Occurring (NO)

NE, IE or NO	IPCC Category	Activity	Comments
NE	1B1b	CO_2, CH_4 and N_2O from spontaneous combustion of coal seams	Researched to be considered in future
	1B1ai2	CH_4 emissions from abandoned mines	Research to be considered in future
	1C1	CO_2 transport	Insufficient data to include
	1C2	Injection and storage	Insufficient data to include

NE, IE or NO	IPCC Category	Activity	Comments
	2B7	CH_4 and N_2O emissions from Soda Ash Production	CO_2 included in this inventory. CH_4 and N_2O will not be included in future
	2C1	N_2O emissions from iron and steel production	Insufficient data to include
	2C2	N_2O emissions from ferroalloy production	Insufficient data to include
	2D2	CH_4 and N_2O emissions from paraffin wax use	Insufficient data to include
	2E	Electronics industry	Insufficient data to include
	2F5	PFCs and HFCs from solvents	Insufficient data to include
	2G1	PFCs from electrical equipment	Insufficient data to include
	2G2	PFCs from other product uses	Insufficient data to include
	2G3	N_2O from product uses	Insufficient data to include
	3B	CO_2 from organic soils	Due to priority this will only be included in the next inventory.
	3C4	N_2O from organic soils	Insufficient data to include
	4B	CH_4, N_2O emissions from biological treatment of waste	Insufficient data to include
	4C1	CO_2, CH_4 and N_2O from waste incineration	Insufficient data to include
	2	SF6 emissions in the IPPU sector	Insufficient data. Some information is included where possible
	All sectors	NOx, CO, NMVOC emissions	These have only been included for biomass burning due to a lack of data in other sectors
	All sectors	SO_2 emissions	Insufficient data
IE	1A1aii	CO_2, CH_4 and N_2O emissions from Combined Heat and Power (CHP) combustion systems	Not separated out but is included within 1A1ai
	1A3eii	CO_2, CH_4 and N_2O emissions from off-road vehicles and other machinery	Included under Road transportation.
	1A5b	Mobile unspecified	Included under 1A3b
	3B	Precursor emissions from controlled burning	Emissions from controlled burning are not separated from biomass

NE, IE or NO	IPCC Category	Activity	Comments
			burning and so are included under Biomass burning (3C1)
	3B	SOC changes for converted land	This data is included under the land remaining land category as Formulation A of the SOC equation was applied.
	3C1	CO_2 emissions from biomass burning	These are not included under biomass burning, but rather under disturbance losses in the Land sector (3B).
NO	2B3	CO_2, CH_4 and N_2O emissions from Adipic acid production	
	2B4	CO_2, CH_4 and N_2O Caprolactam, Glyoxal and Glyoxylic acid production	
	3C7	Rice cultivation	

1.10 Improvements and Recalculations

Improvements were made to emission estimates from each sector and therefore recalculations were completed for the full time-series. As the current inventory applied the AR5 GWPs, the previous inventory data was converted to CO_2 equivalents by using the AR5 GWP in order to gauge the actual impacts of the improvements made. The data shows that the current inventory estimates (excl. LULUCF) are between 0.43% and 5.3% lower than the 2020 inventory estimates, while the estimates including LULUCF are between 0.23% and 4.94% lower than the 2020 estimates except for 2017 when emission were slightly higher.

The Energy sector improvements contribute the most to the reduction in the estimates in this inventory, with an average reduction of 14 294 Gg CO_2e since 2007 compared to the previous inventory. The LULUCF sector showed an average reduction of 16 929 Gg CO_2e between 2003 and 2014, after which it increases emissions by an average of 14 899 Gg CO_2e until 2018. This then changes to a reduction of 9 832 Gg CO_2e in 2020. The Agriculture sector shows an increase in emissions by an average of 5 234 Gg CO_2e

across the time-series, while Waste emissions are reduced by an average of 7 082 Gg CO_2e over the same period.

1.11 Improvement Plan

A National Greenhouse Gas Improvement Programme (GHGIP) is being implemented to improve activity data, country-specific methodologies and emission factors used in the most significant sectors. It is through the GHGIP that the country is working to resolve the main challenge to the GHG inventory on available data. Table 1.4 presents a summary of projects under implementation and the status of tasks.

Table 1.4: List of planned improvements for South Africa's GHG inventory

Sector	Improvement	Priority	Reason	Status	Completion timeframe	Barriers and constraints
Completed Tasks						
Energy	CO_2 and CH_4 fugitive emissions from oil and natural gas operations	Medium	Completeness	Completed	2022 inventory	Included in this inventory (2000-2022).
	Fugitive emissions from coke production to be reported separately from 2C process emissions	Low	Transparency	Completed	2022 inventory	Included in this inventory (2000-2022).
	Develop EFs, carbon content of fuels and NCVs of liquid fuels	High	Key category; Accuracy	Completed	2022 inventory	Included in this inventory (2000-2022).
Agriculture	Incorporate all background equations for the Tier 2 calculations of enteric fermentation	High	Key category; Accuracy; Transparency	Completed	2022 inventory	Included in this inventory (2000-2022).
LULUCF	Estimate the HWP contribution based on other approaches.	Medium	Key Category; Accuracy	Completed	2022 inventory	Included in this inventory (2000-2022).
	Incorporate updated National Terrestrial Carbon Sinks Assessment (NTCSA) data to improve estimates, particularly for soils	High	Key category; Accuracy	Resolved		The NTCSA data is not being updated regularly and is not incorporating the latest land cover maps. This data is therefore not being incorporated into the inventory due to issues of sustainability. The general carbon stock data per land type is being used for verification purposes.
	Include CO_2 estimates for wetlands	Low	Accuracy; Completeness	Completed	2022 inventory	Included in this inventory (2000-2022).

Sector	Improvement	Priority	Reason	Status	Completion timeframe	Barriers and constraints
	Included 2018 and 2020 SANLC maps	High	Key category; Accuracy; Completeness	Completed	2022 inventory	Included in this inventory (2000-2022), however there are numerous improvements that need to be made to the LULUCF data so a detailed LULUCF improvement plan has been developed and these ongoing improvements are listed below.
	Justify reason for use of Tier 1 methods for key categories and pools and include moving to higher tiers in the improvement plan.	Medium	Transparency	Completed	2022 inventory	Included in this inventory (2000-2022).
	Highlight the need for a National Forest Inventory	High	Key category; Accuracy	Completed	2022 inventory	Included in this inventory (2000-2022). The need for a national forest inventory was highlighted in the report, and is listed in the improvement plan below as an outstanding task.
	Include growth of biomass of the last 5 years in the maturity cycle in the cropland remaining cropland	Low	Accuracy	Completed	2022 inventory	Included in this inventory (2000-2022).
	Identify significant sub-categories and carbon pools	Medium	Key category; Accuracy	Completed	2022 inventory	Included the pools for each of the land classes and also included these in the KCA.
	Further explain the appropriateness of the country specific EF for CH_4 for wetlands	Medium	Accuracy	Completed	2022 inventory	Included in this inventory (2000-2022). The country specific emission factor was assessed and it was found that it was a very site and condition specific factors, therefore the value was reverted back to the default emissions factor. Another country specific factor was found to be similar to

Sector	Improvement	Priority	Reason	Status	Completion timeframe	Barriers and constraints
						the default factor in support of this change.
Tasks in progress						
Cross-cutting	Improve uncertainty data for all sectors by incorporating more country specific uncertainty values	Medium	Accuracy	In progress	Incorporated as data becomes available	Lack of uncertainty data constrains this activity. As data becomes available it will be incorporated. In this inventory a more detailed analysis of uncertainty for LULUCF sector was completed.
	Improve QA/QC process by addressing all issues in external review	High	Transparency	In progress	Future inventories	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.
Energy	Improve the improvement plan by incorporating all review activities not addressed in current inventory	High	Transparency	In progress	Ongoing	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

Sector	Improvement	Priority	Reason	Status	Completion timeframe	Barriers and constraints
						this report as a reminder of what still needs to be completed.
	Improve explanation of large changes in trends	High	Transparency	In progress	Ongoing	Partly resolved. Additional explanations have been provided, but there are still areas where this can be improved further. Ongoing process.
Agriculture	Incorporate all background data for the Tier 2 calculations of enteric fermentation	High	Key category; Accuracy; Transparency	In progress	2024 inventory	All the background equations have been included, but average data is still being used for the majority of the factors (instead of annual data) due to a lack of a sustainable data source. Data sources are being investigated and data will be included once it becomes available.
	There is a need for an alternate data source for Lime data	Medium	Key category; Accuracy	In progress	2024 inventory	Past inventory reviews have mentioned upgrading this information and investigating the alternate method of calculating potential lime use.
LULUCF	Complete a full uncertainty analysis for the Land sector, including area bias corrections	High	Key category; Accuracy	In progress	2024 inventory	A more detailed uncertainty analysis was included for biomass, DOM and SOC data in the LULUCF sector. Mapping uncertainties were improved; however these will be improved further during the land change improvement plan.

Sector	Improvement	Priority	Reason	Status	Completion timeframe	Barriers and constraints
	Improvement of land change data through detailed assessment of maps and tracking of land parcels	High	Key category; Accuracy; Consistency	In progress	The land use improvement plan will be completed over the next 3 years so data will be incorporated as it becomes available (2024 and 2026 inventory).	This 2022 inventory incorporated a more detailed assessment of the land change data and identified the most important land change categories that need attention. The assessment also identified improvements that need to be done moving forward and the priority of these improvements. Removing changes due to seasonality is top priority and this will be improved as more land change maps are obtained. The 2022 SANLC map will already assist with making improvements. Tracking of land parcels over time is the second most important issue and training on Collect Earth to assist in this process is underway.
	Include deadwood in the DOM pool for all land categories	Low	Completeness	In progress	2024	Deadwood has been included for the forest land category. The other land categories with woody components are settlements and perennial crops, but data is very limited for these land categories. Deadwood in these categories is assumed to be very small, but an explanation of this will be included in the next inventory.

Sector	Improvement	Priority	Reason	Status	Completion timeframe	Barriers and constraints
	Move to a higher tier level for DOM in forest lands	Medium	Key category; Accuracy	In progress	2024	This was considered in the 2022 inventory and more detailed disturbance matrix data was included to determine the amount of biomass entering the DOM pool, however there were still one or two pieces of data missing which requires further investigation. This will be completed and included in the next inventory.
Waste	Data collection on quantities of waste disposed of into managed and unmanaged landfills		Key category; Accuracy	In progress	2024	Project is underway so data will be included in 2024 inventory.
Tasks outstanding						
Cross cutting	Investigate inconsistencies in lime activity data (for lime production in IPPU and lime application emission in Agriculture), explore alternative data sources or improve consistency.	Low	Consistency	Planned	5th BUR	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.
	Incorporate NO_x, CO, NMVOC, and SO_x emissions	High	Completeness	Proposed	5th BUR	Not resolved.
Energy	Further disaggregation of 1A2	Medium	Accuracy	Planned	Future inventories	Current inventory breaks down 1A2 into 1A2a, 1A2b and 1A2-ab. Further work is require to further disaggregate this sector and have emissions calculated per sub-sector.

Sector	Improvement	Priority	Reason	Status	Completion timeframe	Barriers and constraints
	More activity data for estimating emissions associated with non-energy fuel use	Low	Accuracy	Planned	Future inventories	Research to be initiated in future.
	Inclusion of methodology documentation/summary/approval process for tier 3 methods	Low	Transparency	Planned	Future inventories	To be collated and included in future.
	CO_2, CH_4 and N_2O from spontaneous combustion of coal seams	Low	Completeness	Planned	Future inventories	Research to be initiated in future.
	CH_4 emissions from abandoned mines	Low	Completeness	Planned	Future inventories	Research to be initiated in future.
	Investigate pipeline transport	Low	Completeness	Proposed	Future inventories	Proposed but nothing planned.
	Investigate ground activities at airports and harbours	Low	Accuracy	Proposed	Future inventories	Proposed but nothing planned.
	Update of the VKT study, including segregation of on-road/off-road	Medium	Accuracy	Proposed	Future inventories	Proposed but nothing planned.
	Comparison of next VKT approach with fuel statistics	Low	Accuracy	Proposed	Future inventories	Proposed but nothing planned.
	Segregation of military energy use.	Low	Accuracy	Proposed	Future inventories	Proposed but nothing planned.
	Incorporate emissions from biogas	Low	Completeness	Proposed	Future inventories	This would require a study and so should be recommended as a project under the GHGIP.
	CO_2 transport and storage	Low	Completeness	Proposed	Future inventories	Proposed but nothing planned.

Sector	Improvement	Priority	Reason	Status	Completion timeframe	Barriers and constraints
IPPU	CO_2, CH_4 and N_2O emissions from combined heat and power (CHP) combustion systems	Medium	Completeness	Proposed	Future inventories	Proposed but nothing planned.
	Development of T3 methods for CTL-GTC and GTL	Low	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		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 SF_6 emissions	Medium	Completeness	In progress		Lack of data is still a challenge.
Agriculture	Improve manure management data, including biogas digesters as a management system	Medium	Accuracy	Proposed	2024	Proposed project as there is a high variability in this dataset.
LULUCF	Incorporate organic soils study to include emissions from organic soils	Low	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.
	Undertake a National Forest Inventory and include SOC in the inventory	High	Key category; Accuracy	Proposed	Future inventories	This is an activity which would need to be completed by the Department of Forestry, therefore the date for completion is not known.
	Complete an assessment of crop types and areas and investigate discrepancies between crop statistics and NLC data	Medium	Consistency; Comparability	Planned	2024 inventory	This was partially investigated in this inventory; however, a proper assessment will be included in the land use change improvement

Sector	Improvement	Priority	Reason	Status	Completion timeframe	Barriers and constraints
						plan that will run over the next few years.
	Perform a more detailed assessment of HWP to include a wider range of products	Medium	Key category; Accuracy	Proposed		Proposed project that could be considered under the GHGIP. For future evaluation.
	Report activity data and parameters (e.g. half-life) used for HWP emission estimation for the whole time-series	Medium	Transparency	Planned	2024 inventory	This will be included in the 2024 inventory.
	Report on the frequency of the HWP activity data collection	Low	Transparency	Planned	2024 inventory	This will be included in the 2024 inventory.
	Assess if the emissions/removals in the overseas territories are significant	Low	Completeness	Planned	2024 inventory	Currently these emissions are assumed insignificant as the area of these territories is extremely small, but an assessment of possible emissions still needs to be explored.
	Collect data on other disturbances besides fire in forest lands	Low	Key category; Accuracy	Proposed	Future inventory	This would require a study so will be recommended as a project under the GHGIP.
	Develop a spatial map of fuel wood consumption based on literature to further improve fuel wood consumption	High	Key category; Accuracy	Proposed	Future inventory	This would require a study so will be recommended as a project under the GHGIP.
	Assess the significance of peatlands	Low	Completeness	Proposed	2026 inventory	Assessing the areas of peatlands would be the first step and this part could be done as part of the land use improvement plan.

Sector	Improvement	Priority	Reason	Status	Completion timeframe	Barriers and constraints
Waste	Improve MCF and rate constants	Medium	Key category; Accuracy	Proposed		This would require a study so will be recommended as a project under the GHGIP.
	Include economic data for different population groups	Medium	Key category; Accuracy	In progress	2024 inventory	Will be included in the 2024 inventory
	Include information on population distribution in rural and urban areas as a function of income	Medium	Key category; Accuracy	In progress	2024 inventory	Insufficient data.
	Include HWP in solid waste	Medium	Key category; Completeness	Proposed	Future inventory	Once HWP data is improved (see above) it will be incorporated into solid waste.
	Obtain data on waste streams and the bucket system	Medium	Accuracy	In progress	2024 inventory	Insufficient data.
	CH_4, N_2O emissions from biological treatment of waste	Medium	Completeness	In progress	2024 inventory	Insufficient data.
	CO_2, CH_4 and N_2O from waste incineration	High	Completeness	In progress	2024 inventory	Insufficient data.

1.12 Approval and publishing process

The Biennial Transparency Report (BTR) and National Inventory Reports (NIRs) are endorsed by the Project Steering Committee (PSC) before being submitted to the Minister of the DFFE for approval. The PSC is chaired by the DFFE and comprises of various state departments. Once the reports are approved by Minister, they are submitted to the UNFCCC by the Chief Directorate for Climate Change International Relations and Reporting and undergo an international review process.

1.13 Application of flexibility provisions

Under **Paragraph 48** of the MPGs it is stated that each Party shall report seven gases (CO_2, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF6) and nitrogen trifluoride (NF3)); those developing country Parties that need flexibility in the light of their capacities with respect to this provision have the flexibility to instead report at least three gases (CO_2, CH_4 and N_2O) as well as any of the additional four gases (HFCs, PFCs, SF6 and NF3) covered by an activity under Article 6 of the Paris Agreement, or have been previously reported. This provision has been applied to the current inventory as South Africa is not reporting on NF3.

Under **Paragraph 57** of the MPGs it is stated that each Party shall report a consistent annual time series starting from 1990; those developing country Parties that need flexibility in the light of their capacities with respect to this provision have the flexibility to instead report data covering, at a minimum, the reference year/period for its NDC under Article 4 of the Paris Agreement and, in addition, a consistent annual time series from at least 2020 onwards.

This provision has been applied to the current inventory. Due to data availability South Africa is reporting a time series starting from 2000 and not 1990, that aligns with the reference year for the country's NDC under Article 4 of the Paris Agreement.

1.14 Trends in GHG emissions

1.14.1 National GHG inventory Emissions for 2022

The 2022 National Inventory Document for South Africa is the country's 9th inventory report and provides estimates of South Africa's net GHG emissions for the period 2000 to 2022 and will be submitted to United Framework Convention on Climate Change (UNFCCC) to fulfil South Africa's reporting obligations under the UNFCCC.

National emissions of CO_2, CH_4 and N_2O and GHG precursors for 2022 are provided in Table 1.5.**Error! Reference source not found.**

Emissions of GHG precursor gases (NO_x, CO and NMVOCs) are only estimated from Biomass burning. Global Warming Potentials (GWPs)) from the 2014 IPCC Fifth Assessment Report (AR5) were used.

Table 1.5: Summary emission table for South Africa for 2022

IPCC 2006 category	Emissions and removals									
	Net CO_2	CH_4	N_2O	HFCs	PFCs	SF6	NOx	CO	NMVOC	Total GHGs
	(Gg)			(Gg CO_2e)			(Gg)			(Gg CO_2e)
Emissions (incl. LULUCF)	335 992.1	2 652.2	73.4	5 944.8	125.9	65.7	106.6	2 241.9	211.3	435 827.7
Emissions (excl. LULUCF)	392 138.4	2 258.6	65.6	5 944.8	125.9	65.7	1.6	57.2	0.0	478 887.5
1 - Energy	**365 688.0**	**210.0**	**9.4**							**374 072.4**
1.A - Fuel Combustion Activities	341 775.9	36.1	9.4				NE	NE	NE	345 274.5
1.B - Fugitive emissions from fuels	23 912.1	173.9	0.1				NE	NE	NE	28 797.9
1.C - Carbon dioxide Transport and Storage	NE									NE
2 - Industrial Processes and Product Use	**23 976.1**	**4.3**	**1.4**	**5 944.8**	**125.9**	**65.7**				**30 598.0**
2.A - Mineral Industry	6 055.1	NE								6 055.1
2.B - Chemical Industry	1 267.7	4.3	1.4							1 753.1
2.C - Metal Industry	15 528.5	0.0	0.0	NE	125.9					15 654.6
2.D - Non-Energy Products from Fuels and Solvent Use	1 124.8	NE	NE							1 124.8
2.E - Electronics Industry	NE		NE	NE	NE					NE
2.F - Product Uses as Substitutes for Ozone Depleting Substances	NE			5 944.8	NE					5 944.8
2.G - Other Product Manufacture and Use			NE	NE	NE	65.7				65.7
2.H - Other	NA	NA	NA							NA
3 - Agriculture	**2 445.4**	**1 362.2**	**48.8**				**1.6**	**57.2**		**53 518.7**

IPCC 2006 category	Emissions and removals									
	Net CO_2	CH_4	N_2O	HFCs	PFCs	SF6	NOx	CO	NMVOC	Total GHGs
	(Gg)			(Gg CO_2e)		(Gg)				(Gg CO_2e)
3.A – Enteric fermentation		1 298.3								36 352.1
3.B – Manure management		62.2	9.6							4 284.5
3.C – Rice cultivation		NO								NO
3.D – Agricultural soils		NA	39.2				NE	NE	NE	10 378.1
3.E – Prescribed burning of savannas		IE	IE				IE	IE	IE	IE
3.F – Field burning of agricultural residues		1.7	0.0				1.6	57.2	NE	58.5
3.G – Liming	1 860.7									1 860.7
3.H – Urea application	584.7									584.7
3.I – Other carbon-containing fertilisers	NE									NE
4 - LULUCF	**-56 146.3**	**393.6**	**7.8**				**105.1**	**2 184.7**	**211.3**	**-43 059.8**
4.A – Forest land	-90 082.4	57.7	3.4				57.7	1 421.2	150.1	-87 558.8
4.B - Cropland	3 508.9	IE	IE				IE	IE	IE	3 508.9
4.C - Grassland	10 576.8	25.2	2.3				42.8	713.2	55.3	11 893.4
4.D - Wetland	747.9	310.6	2.1				4.4	47.6	5.7	9 989.2
4.E - Settlements	258.5	0.1	0.0				0.2	2.7	0.2	263.6
4.F – Other land	19 025.4	NO	IE				NO	NO	NO	19 025.4
4.G – Harvested wood products	-181.4									-181.4
5 - Waste	**28.9**	**682.1**	**5.9**							**20 698.4**
5.A - Solid Waste Disposal		307.0	NE							8 596.0

IPCC 2006 category	Net CO_2	CH_4	N_2O	HFCs	PFCs	SF6	NOx	CO	NMVOC	Total GHGs
	Emissions and removals									
	(Gg)			(Gg CO_2e)		(Gg)				(Gg CO_2e)
5.B - Biological Treatment of Solid Waste		62.0	3.0							2 530.4
5.C - Incineration and Open Burning of Waste	28.9	8.7	0.2							325.4
5.D - Wastewater Treatment and Discharge		304.4	2.7							9 246.7
5.E – Other	NO	NO	NO							NO
Memo items										
International bunkers	**3 673.2**	**0.1**	**0.1**							**3 703.8**
International aviation	2 311.0	0.0	0.1							2 328.2
International water-borne transport	1 362.1	0.1	0.0							1 375.7
Multilateral operations	NA	NA	NA							NA

1.14.2 Trends in GHG emissions and removals since 2000

1.14.2.1 Overall emissions (excluding LULUCF)

Overall emissions (excl. LULUCF) include those from Energy, IPPU, Agriculture and Waste. It does not include the sources and removals from land use change and *Harvested wood products*, which together form the LULUCF sector.

1.14.2.2 2000 - 2022

South Africa's GHG emissions excl. LULUCF were 489 748 Gg CO_2e in 2000 and these decreased by 2.2% by 2022. Emissions (excl. LULUCF) in 2022 were estimated at 478 888 Gg CO_2e. The decrease in emissions compared to 2020 is attributed to the marginal decrease in emissions across all the sectors (Energy, IPPU, Agriculture and Waste).

Emissions (excl. LULUCF) in 2022 were estimated at 478 888 Gg CO_2e, this represents an increase of 1,4% compared to 2020 and was influenced by increased activities post the COVID-19 pandemic in the manufacturing sector.

Annual emissions data for South Africa from 2000 to 2022, both excluding and including LULUCF, measured in gigagrams of carbon dioxide equivalent (Gg CO_2e) is shown in Figure 1.5. Notable points include a peak in emissions in 2004 at 524 903 Gg CO_2e, a dip in 2010 with a 3.71% decrease, and a significant decline in 2020 by -5.79%. The emissions increased in 2021 by 3.36% due to post COVID-19 economic recovery. The data reflects South Africa's ongoing journey to balance economic development with environmental sustainability.

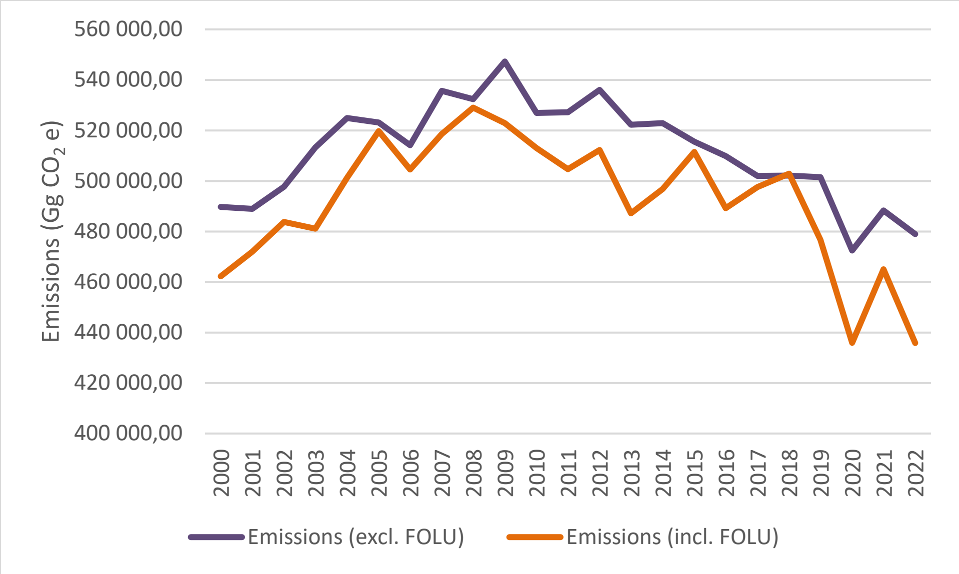

Figure 1.5: National GHG emissions (excluding and including FOLU) for South Africa, 2000 – 2022.

1.14.2.3 Emission Trends by Sector

a. Energy

The Energy sector is the largest contributor to South Africa' emissions (excl. LULUCF), contributing 78% in 2022 and on average since 2000. Since 2000, the Energy sector emissions have decreased by 2.5% with the biggest decrease (6.4%) being in 2020 due to COVID-19 lockdown restrictions. In 2021 emissions increased by 3.5% and then dropped by 3.4% in 2022 to pandemic levels (2020). This decrease is due to a 6.5% decrease in emissions from the *Energy Industries* sub-sector, which on average accounts for 67% of the Energy sector emissions (Figure 1.6).

b. IPPU

In 2022 the IPPU sector produced 30 598 Gg CO_2e which is 6.4% of South Africa's emission (excl. LULUCF). The IPPU sector produces CO_2 emissions (78.4%), fluorinated gases (20.0%) and smaller amounts of CH_4 (0.4%) and N_2O (1.2%). CO_2 and any other emissions from combustion of fuels in these industries are reported under the energy sector. The largest source category is the *Metal industry* category. which contributes 51.2% to the total IPPU sector emissions. The *Mineral industry* and the *Product used as substitutes for ozone depleting substances* subsectors contribute 19.8% and 19.4%, respectively, to the IPPU sector emissions.

IPPU sector emissions are estimated to 2 183 Gg CO_2e (-6.7%) lower than the emissions in 2000 and is attributed to the decline in global demand for Iron and Steel, and Aluminium, resulting metals production to decline by 39.0%. The chemicals industry also declined (-31.4%) whereas the local demand for cement increased dramatically from 2000 resulting in increased emissions from 2000 by 2 081 Gg CO_2e in *Cement Production* and *Non-Energy Product Use from Fuels and Solvents*.

c. Agriculture

The Agriculture sector contributed between 10% and 12% to the total emissions (excl. LULUCF) between 2000 and 2022. The overall emissions have declined by 8.9% since 2000. The main driver of change in the Agriculture sector is the livestock population. Livestock have input into the *Enteric fermentation*, *Manure management,* as well as *Direct* and *Indirect N_2O emissions from managed soils*. *Enteric fermentation* emissions show a declining trend due to a decline in livestock population. Dairy cattle, pigs and poultry are the largest contributors to *Manure management* emissions, and with increasing poultry numbers these emissions increase over the 22- year period.

The Agriculture sector produced 53 519 Gg CO_2e (excl. LULUCF) in 2022. Livestock contributed 76% to the Agriculture emissions in 2022, and the largest contributor to this category is CH_4 from *Enteric fermentation* (68%), while *Manure management* contributed (8%) to the total livestock emissions. Agricultural soils contributed 19 % to the total Agriculture emissions, while the least emissions were from *Liming* (3%), *Urea application* (1.1%) and *Field burning of agricultural residues* (0.1%).

d. LULUCF

The LULUCF sink was estimated at 43 060 Gg CO_2e in 2022. Forest lands were estimated to have a sink of 87 559 Gg CO_2e, with 62% of this being due to land being converted to *Forest lands*. The conversion of *Grasslands* to *Forest land* (mainly woodlands) accounted for 86.3% of the total land conversion sink. All other land categories were sources of emissions with *Other lands* contributing the most (42.5%) to this source, followed by *Grasslands* (26.6%). All the emissions for *Other lands* were from land being converted to bare ground and the largest conversion was low shrublands to bare ground.

The LULUCF sector showed an increase of 56.3% in its sink since 2000. The sink increased by 17.9% since 2020. The sink was reduced between 2015 and 2018, and these changes were brought about by the change in land conversions introduced by the 2014-2018 change maps. During this period there was an increase in the emissions from *Grasslands* (due mainly to conversion between low shrubland and grasslands) and *Croplands*. The increased *Cropland* emissions were attributed to an increase in conversion of *Forest land* to *Cropland* and conversions between perennial and annual crops. These increased emissions led to a reduction in the sink during this period.

Grasslands were estimated to be a small sink between 2000 and 2014, but the trends show that from 2015 onwards the become a source of emissions. This is due to the conversions between low shrublands and grasslands, however this is one of the categories that can be impacted by seasonal variation. The land change improvement plan will investigate these changes further over the next few years in the aim of better understanding the changes and reducing the uncertainty.

The trends also show an increase in the *Forest land* sink. There is an increase in conversion of *Grassland* to *Forest land*, mainly grasslands to woodlands, which also supports the findings of a reduced *Grassland* sink. Thickets are an important sink in the *Forest land* category and the sink is seen to be fairly stable, however thickets are the land category that showed the most change in the land change maps due to reclassification, so the improvement plan will interrogate this further.

e. Waste

In South Africa the total Waste sector emissions for 2022 were 20 698 Gg CO_2e. Most of these emissions are from *Wastewater treatment and discharge* contributing 9247 Gg CO_2e (44.1%) of the total Waste sector emissions. *Solid waste disposal* contributed a further 8 596 Gg CO_2e (41.5%) of waste emissions while *biological treatment of solid waste* contributed 2 530 Gg CO_2e (12.2%). Emissions from *Incineration and Open Burning of Waste* were estimated to be 325 Gg CO_2e (1.57%).

Solid waste disposal emissions have increased 47.6% since 2000. *Incineration and open burning of waste* emissions increased by 53.1% since 2000, while emissions from *Wastewater treatment and discharge* increased slightly across the time series. This overall increase in emissions is largely driven by increases of 35.6% in *Domestic wastewater treatment and discharge* emissions, whilst there was a 9.4% decline in *Industrial wastewater treatment and discharge* emissions.

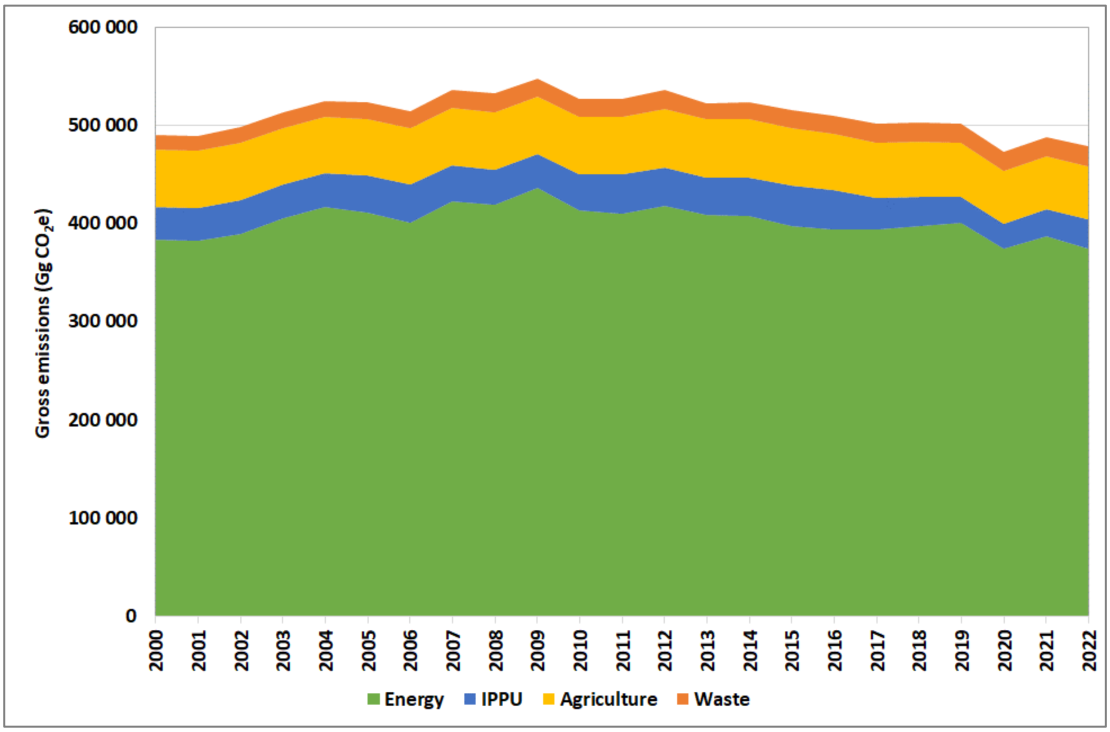

Figure 1.6: Trend in emissions by sector for 2000 to 2022.

1.14.3 Emission Trends by Gas

1.14.3.1 Carbon Dioxide (CO_2)

CO_2 is the largest contributor to South Africa's emissions; followed by CH_4 and then N_2O. CO_2 emissions contributed 81.9% (excl. LULUCF) to South Africa's emissions in 2022. The majority of CO_2 emissions are from the Energy sector, contributing an average of 92.7% (excl. LULUCF) to the total CO_2 emissions between 2000 and 2022. The IPPU sector's contribution (excl. LULUCF) is an average of 6.8% of the total CO_2 emissions between 2000 and 2020, while the Agriculture sector contributed an average of 0.6%. The trend and contribution of each sector to CO_2 emissions can be seen in

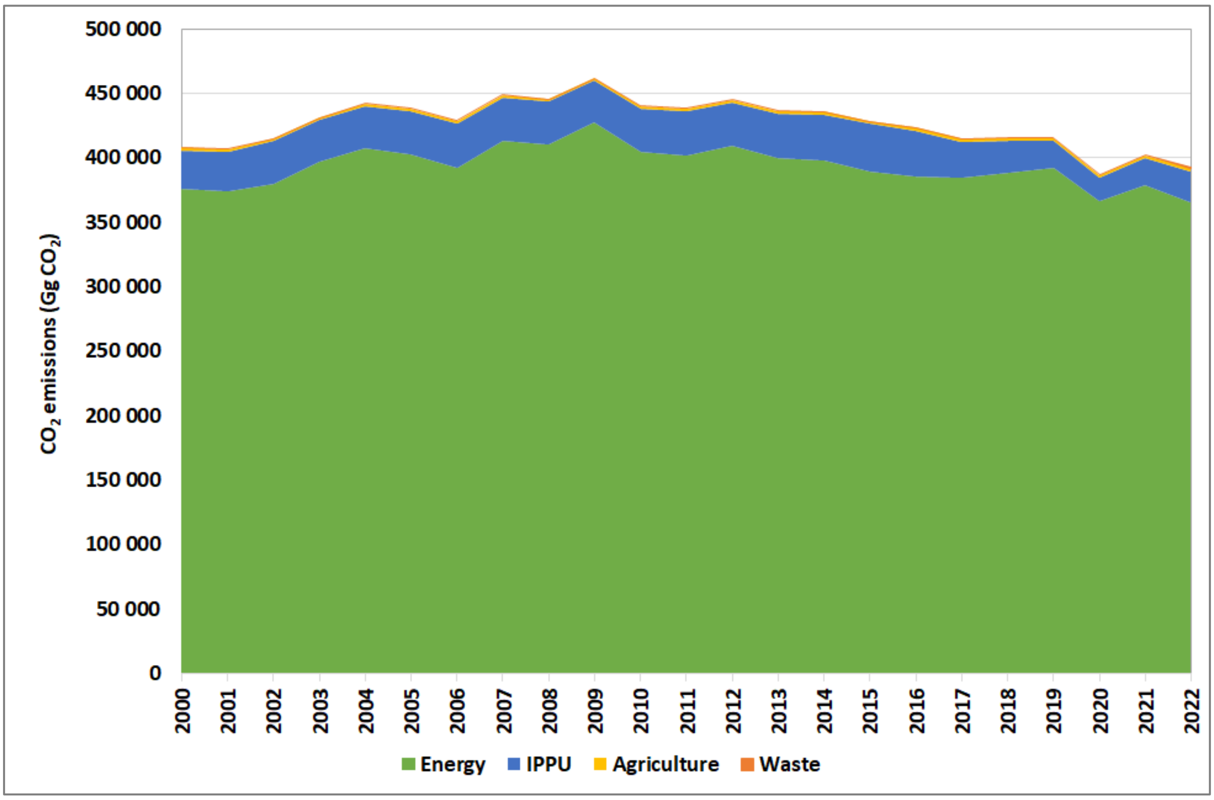

Figure 1.7.

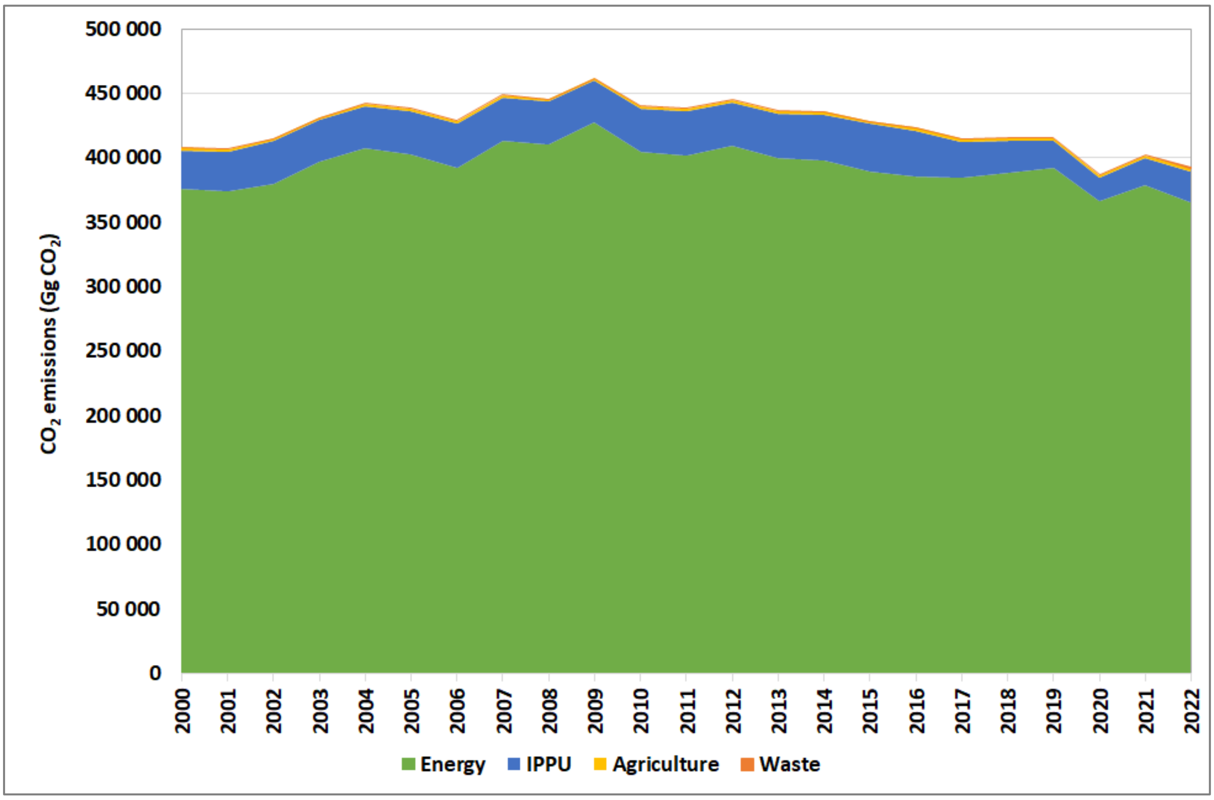

Figure 1.7: Trend and sectoral contribution to CO_2 emissions (excl. LULUCF), 2000 – 2022.

1.14.3.2 Methane (CH_4)

The trend and contribution of all the sectors to the total CH_4 emissions in South Africa are shown in Figure 1.8. CH_4 emissions (excl. LULUCF) only increased by 0.02% between 2000 and 2022. The *Enteric Fermentation* from Agriculture and *Solid Waste Disposal* from Waste were the major contributors to the total CH_4 emissions in 2022.

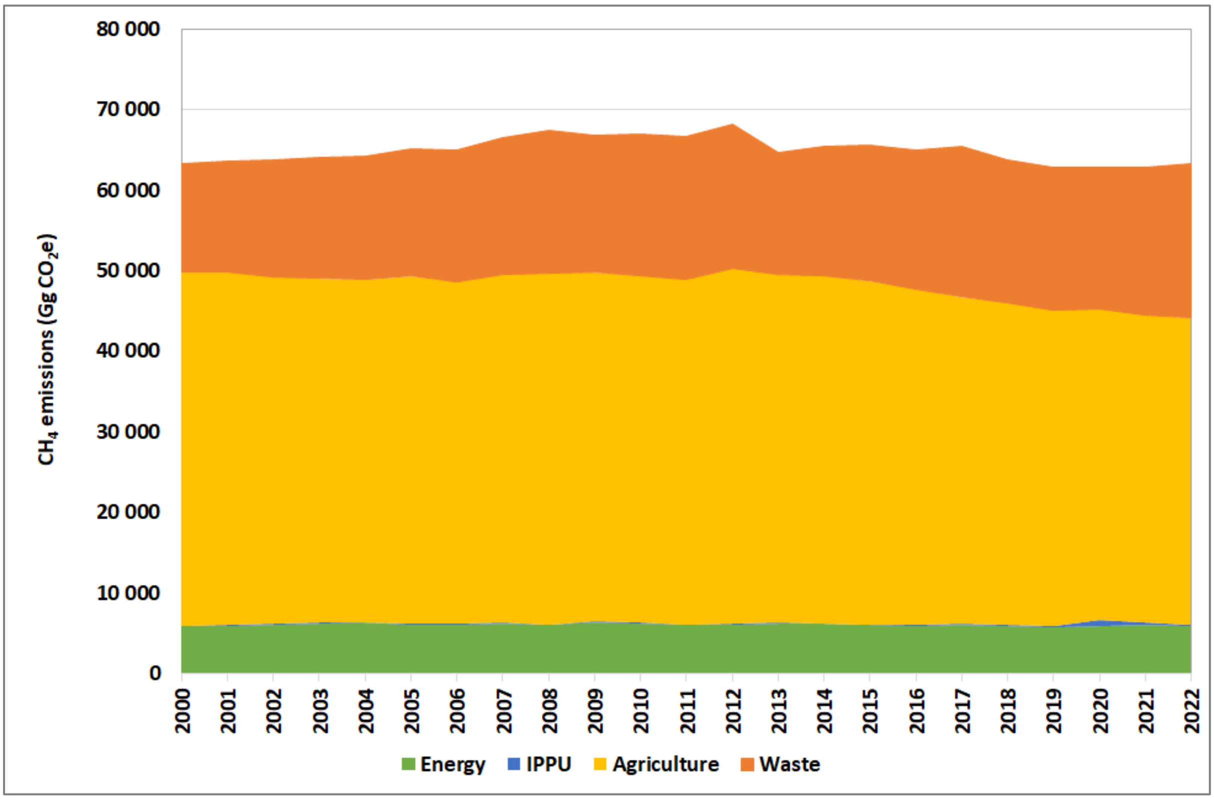

Figure 1.8: Trend and sectoral contribution to the CH_4 emissions, 2000 – 2022.

1.14.3.3 Nitrous oxide (N_2O)

The contribution of all the sectors to the N_2O emissions is shown in Figure 1.9. The main contributor to N_2O emissions is the Agriculture sector followed by Energy sector, contributing 74.4% and 14.4% (excl. LULUCF) respectively. N_2O emissions for 2022 from IPPU sector have decreased by 74.0% since 2000.

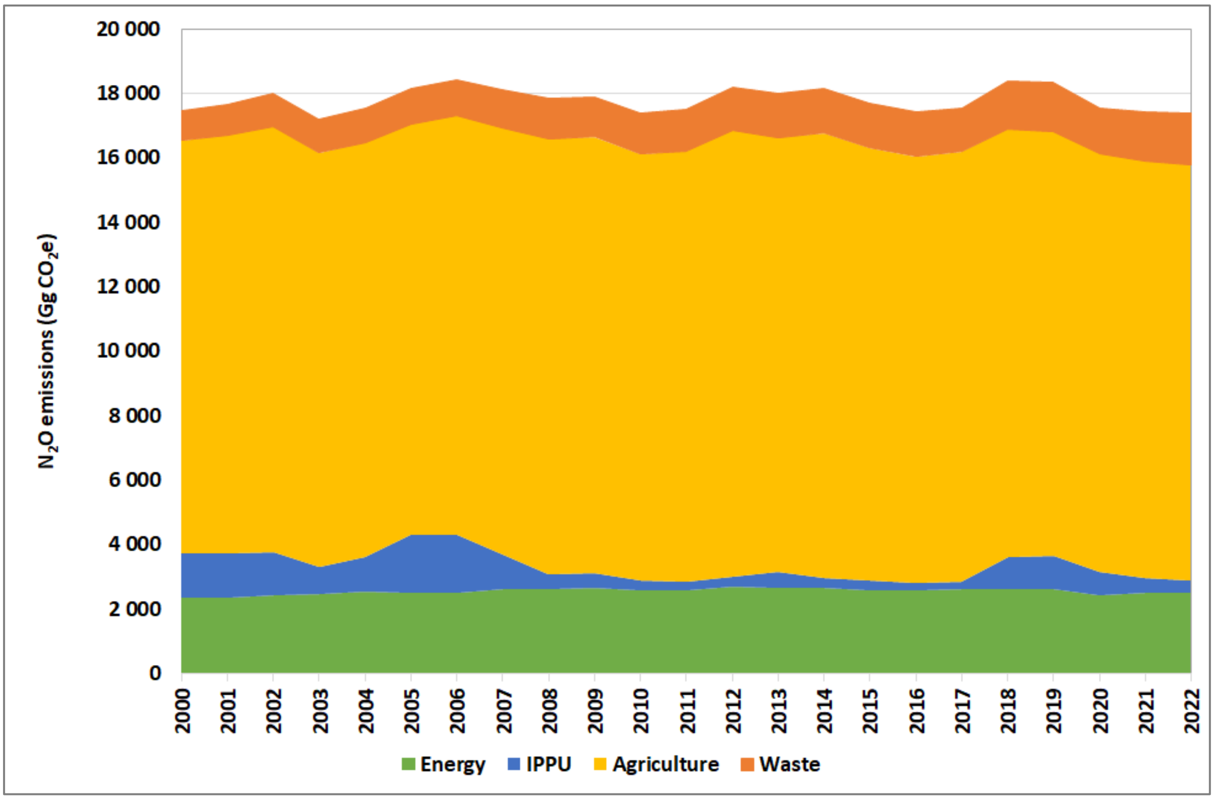

Figure 1.9: Trend and sectoral contribution to N_2O emissions in South Africa, 2000 – 2022.

1.14.3.4 F gases

Estimates of HFC and PFC emissions were only estimated for the IPPU sector in South Africa (Figure 1.10). F-gases contributed 1.3% to overall emissions (excl. LULUCF) in 2022 and emission estimates vary annually. This time-series is not consistent as there is no data prior to 2005. The emissions increase from 2011 is due to the addition of data on HFC emissions from air conditioning, foam blowing agents, fire protection and aerosols. The elevated F-gas emissions are therefore not necessarily due to an increase in emissions but rather due to the incorporation of new categories.

PFCs are produced during the production of aluminium. The *Aluminium production* data were updated for the years 2014 onwards and the updated data were an order of magnitude lower than the previous years, resulting in the decline in the PFC emissions. There was a sharp decline in emissions from the *Metal industry* between 2007 and 2009 and this is attributed to reduced production caused by electricity supply challenges and decreased demand following the economic crisis that occurred during

2008/2009. Increases in 2011 and 2012 were due to increased emissions from aluminium plants due to inefficient operations, due to switching on and off at short notice due to rotational electricity load shedding.

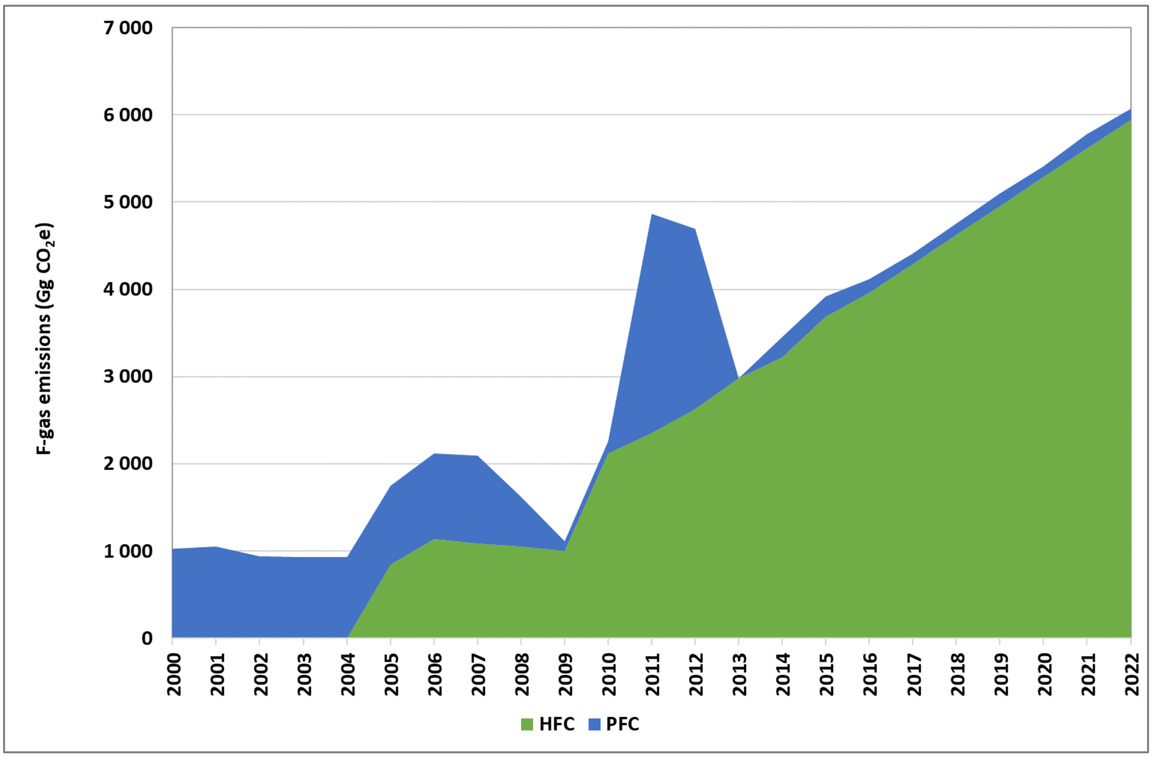

Figure 1.10: Trend in F-gas emissions in South Africa, 2000 – 2022.

1.14.4 Trends in Indirect GHG Emissions

The trend in emissions of CO, NO_x and NMVOCs is shown in Table 1.6. These emissions were estimated for biomass burning only, and as the emissions include wildfires as well as controlled fires, there is annual variability.

Table 1.6: Trends in indirect GHG emissions between 2000 and 2022.

	NO_x	CO	NMVOC
	(Gg)		
2000	98.3	1 994.2	187.2
2001	121.3	2 446.9	228.7
2002	136.8	2 775.0	259.8
2003	82.5	1 755.8	171.0
2004	87.9	1 833.6	176.0
2005	141.4	2 908.0	275.7
2006	119.9	2 473.1	235.1
2007	103.5	2 371.6	242.2
2008	127.9	2 799.2	277.2
2009	100.8	2 119.8	204.5
2010	127.9	2 613.1	246.2
2011	118.1	2 350.0	217.4
2012	118.0	2 450.2	233.3
2013	93.0	1 981.2	193.5
2014	105.5	2 251.8	219.8
2015	76.3	1 555.6	147.9
2016	44.8	945.2	91.9
2017	83.6	1 710.8	163.0
2018	90.3	1 915.6	187.4
2019	80.9	1 741.1	172.7
2020	80.3	1 666.3	161.6
2021	140.7	2 897.5	279.3
2022	105.1	2 184.7	211.3

1.14.5 Time-Series Consistency

Time-series inconsistencies were noted in the Energy and IPPU sectors.

1.14.5.1 1A1a Electricity and heat production

The time-series for 1A1a *Electricity and heat production* is incomplete with regards to fuel consumption data for diesel from other electricity producers prior to 2019. In the last two years diesel has not contributed more than 0.6% to the total fuel consumption for other electricity producers.

Additionally, the time-series is not consistent because from 2019 onwards data from the SAGERS is used as it is regarded to be more accurate.

1.14.5.2 1A1b Petroleum refining

The time-series for 1A1b *Petroleum refining* is incomplete with regards to fuel consumption data for diesel, natural gas, MRG and LPG prior to 2019. In the last two years these fuels have not contributed more than 8% to the total fuel consumption for the sub-category. Additionally, the time-series is not consistent because from 2019 onwards data from the SAGERS is used as it is regarded to be more accurate.

1.14.6 For IPPU:

The *Other Process Uses of Carbonates* is a new category introduced to the inventory in 2018. This has resulted in an inconsistent time series as historical data is unavailable currently. The time series consistency will be updated as industry continues to report in future via the SAGERS Portal.

Ferroalloys production (.C.2): The time series is not consistent due to a change in data sources in 2018 and 2019. From 2020 industry reported via the SAGERS through the GHG Reporting Programme brought better consistency

Hydrogen Production (2.B.8.g): The time series is not consistent as hydrogen production is a new category added in 2018. Historical data is not available. The time series will be built on in future as more data becomes available.

Aerosols (2.F.4). Time series is not consistent over the full 20-year period as emission data for this sub-category is only available from 2011. Due to a lack of consistency in data availability, activity data was assumed to be the same from 2016.

1.15 SECTORAL ANALYSIS

1.15.1 Energy

The primary energy supply for South Africa is dominated by coal and crude oil. South Africa's energy intensity is high mainly due to the economy being dominated by large-scale, energy-intensive primary minerals beneficiation industries and mining industries. Furthermore, there is a heavy reliance on fossil fuels for the generation of electricity and to produce a significant proportion of the liquid fuels consumed in the country.

South Africa's Energy sector inventory includes:

- Exploration and exploitation of primary energy sources;
- Conversion of primary energy source into more useable energy forms in refineries and power plants;
- Transmission and distribution of fuels; and
- Final use of fuels in stationary and mobile applications.

The Energy sector is South Africa's largest emitting sector. This sector is the largest source of CO_2 emissions and the second largest source of N_2O emissions mainly because of *Fuel Combustion* activities.

1.15.1.1 Trends

Total emissions from the Energy sector for 2022 are shown in Table 1.7. Emissions from *Fuel Combustion* activities accounted for 92% of the Energy sector emissions, with *Energy Industries* accounting for 65 % of emissions from *Fuel Combustion* activities.

Table 1.7: Summary of emissions from the Energy sector in 2022

Greenhouse gas source and sink categories	CO_2	CH_4		N_2O		Total
	Gg CO_2e	Gg	Gg CO_2e	Gg	Gg CO_2e	Gg CO_2e
1. ENERGY	**365 688**	**210**	**5 881**	**9**	**2 492**	**374 061**
1A Fuel combustion activities	341 776	36	1 011	9	2 487	345 274
1B Fugitive emissions from fuels	23 912	174	4 870	0	5	28 787
1C CO_2 transport and storage	NE	NE	NE	NE	NE	NE

The changes in Energy sector emissions since 2000, at an aggregated level, are shown in Figure 1.11. The impact of stringent lockdown restrictions in 2020, due to the COVID-19 pandemic, is seen in the drop in emissions. Thereafter emissions increased in 2021 as less stringent measures were put in place in the first half of the year and all restrictions were then revoked for the remainder of the year.

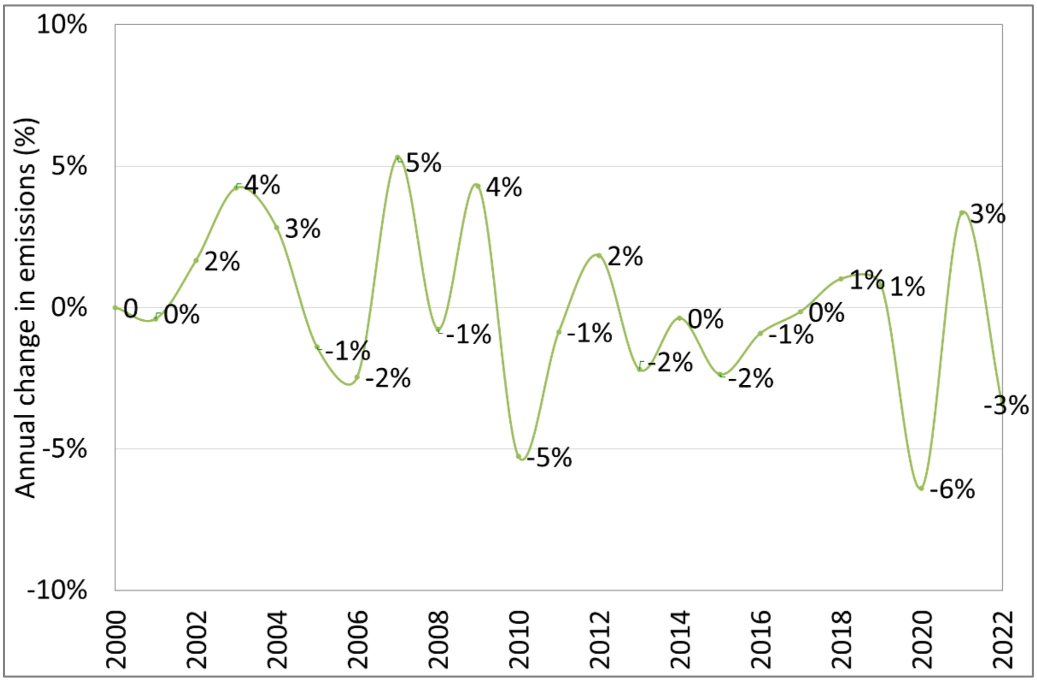

Figure 1.11. Trend in annual change in the total energy emissions in South Africa, 2000 – 2022.

The highest percentage increase in emissions since 2000 was experienced by the *Transport* and the *Manufacturing industries and construction* sub-sectors. This is due to a growing population and to growth in the manufacturing industry resulting in increased energy demand. Similarly, since 2020 the *Manufacturing industries and construction* sub-sector experienced the highest increase in emissions. This was because of increased demand in production following a temporary drop in 2020 caused by stringent lockdown restrictions.

The highest percentage decrease in emissions since 2000 was experienced by the *Other Sectors* sub-sector mainly due to a significant decrease in emissions from households due to increased electrification across the country since 2000 as well as an increase in residential solar installations.

1.15.1.2 Methods and data

Emissions for the *Energy* sector was estimated with a sectoral approach. Table 1.8 a summary of the methods and emission factors applied to each subsector.

Table 1.8: Summary of methods and emission factors for the energy sector and an assessment of the completeness of the energy sector emissions.

GHG Source and sink category		CO_2		CH_4		N_2O		NO_x	CO	NMVOC	SO_2
		Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor				
1A	Fuel combustion activities										
1A1	*Energy industries*										
	a. Main activity electricity and heat production	T2	CS	T1	DF	T1	DF	NE	NE	NE	NE
	b. Petroleum refining	T1, T2	DF, CS	T1	DF	T1	DF	NE	NE	NE	NE
	c. Manufacture of solid fuels and other energy industries	T3	CS	T3	CS	T3	CS	NE	NE	NE	NE

GHG Source and sink category		CO_2 Method applied	CO_2 Emission factor	CH_4 Method applied	CH_4 Emission factor	N_2O Method applied	N_2O Emission factor	NO_x	CO	NMVOC	SO_2
1A2	***Manufacturing industries and construction***	T1, T2	DF, CS	T1	DF	T1	DF	NE	NE	NE	NE
1A3	***Transport***										
	a. Civil aviation	T1	CS	T1	DF	T1	DF	NE	NE	NE	NE
	b. Road transportation	T2	CS	T1	DF	T1	DF	NE	NE	NE	NE
	c. Railways	T2	CS	T1	DF	T1	DF	NE	NE	NE	NE
	d. Water-borne navigation	T2	CS	T1	DF	T1	DF	NE	NE	NE	NE
	e. Other transportation	NO		NO		NO		NO	NO	NO	NO
1A4	***Other sectors***										
	a. Commercial/ Institutional	T1, T2	DF, CS	T1	DF	T1	DF	NE	NE	NE	NE
	b. Residential	T1, T2	DF, CS	T1	DF	T1	DF	NE	NE	NE	NE
	c. Agriculture/ Forestry/ Fishing/ Fish farms	T1, T2	DF, CS	T1	DF	T1	DF	NE	NE	NE	NE
1A5	***Non-specified***										
	a. Stationary	T1, T2	DF, CS	T1	DF	T1	DF	NE	NE	NE	NE
	b. Mobile	IE		IE		IE		IE	IE	IE	IE
1B	**Fugitive emissions from fuels**										
1B1	***Solid fuels***										
	a. Coal mining and handling	T2	CS	T2	CS						
	b. Uncontrolled combustion and burning coal dumps	NE		NE		NE		NE	NE	NE	NE
	c. Solid fuel transformation	T1	DF	T1	DF	T1	DF	NE	T1	NE	NE
1B2	***Oil and natural gas***										

GHG Source and sink category		CO_2 Method applied	CO_2 Emission factor	CH_4 Method applied	CH_4 Emission factor	N_2O Method applied	N_2O Emission factor	NO_x	CO	NMVOC	SO_2
	a. Oil	T3		T3		T3		NE	NE	NE	
	b. Natural gas	T3		T3		T3		NE	NE	NE	
1B3	***Other emissions from energy production***	T3		T3		NO		NE	NE	NE	NE
1C	**Carbon dioxide transport and storage**										
1C1	***Transport of CO_2***										
	a. Pipelines	NE									
	b. Ships	NE									
	c. Other	NE									
1C2	***Injection and storage***										
	a. Injection	NE									
	b. Storage	NE									
1C3	***Other***	NE									

1.15.1.3 Reference and sectoral approach comparison

The emissions reported for *Fuel combustion* activities are estimated using the Sectoral Approach. The Reference Approach was also used estimate emissions and the comparison of the two approaches is shown in Figure 1.12. The comparison is done until 2020 in accordance with the latest energy balance data from the DMRE. The Reference Approach resulted in higher estimates than the Sectoral Approach, as was the case with previous inventories. On average the Sectoral Approach has resulted in estimates that are 19% lower since 2000.

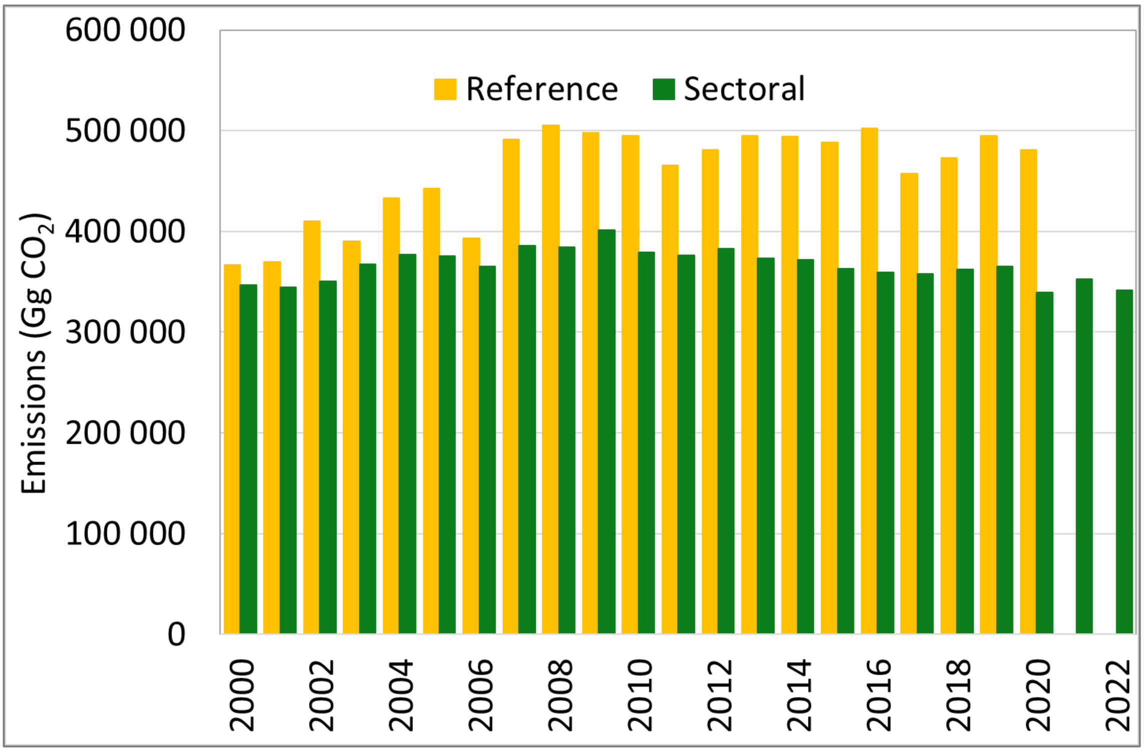

Figure 1.12. Comparisons between the reference and sectoral approach of determining the CO_2 emissions for the energy sector for South Africa.

1.15.1.4 Recalculations

Recalculations were performed for the Energy sector because of the following reasons:

- The use of country-specific emission factors for commonly used liquid and gas fuels. The emission factors result from a study that was completed in 2022. Emissions from the entire time-series were recalculated for the applicable *Fuel combustion* activities.
- Estimates from 1A2 were recalculated based on data from SAGERS and disaggregated to include emissions from 1A2a *Iron & Steel*, 1A2b *Non-ferrous Metals* and 1A2-ab the remainder of 1A2.
- Inclusion of emissions from charcoal and coke production under 1B1c for the entire time-series.

- Recalculation of 2019 and 2020 emissions estimates, where applicable[1], based on the updated activity data from the energy balance.

The improvements mentioned above resulted in the current inventory being 2.3% lower than the previous inventory estimates (Figure 1.13).

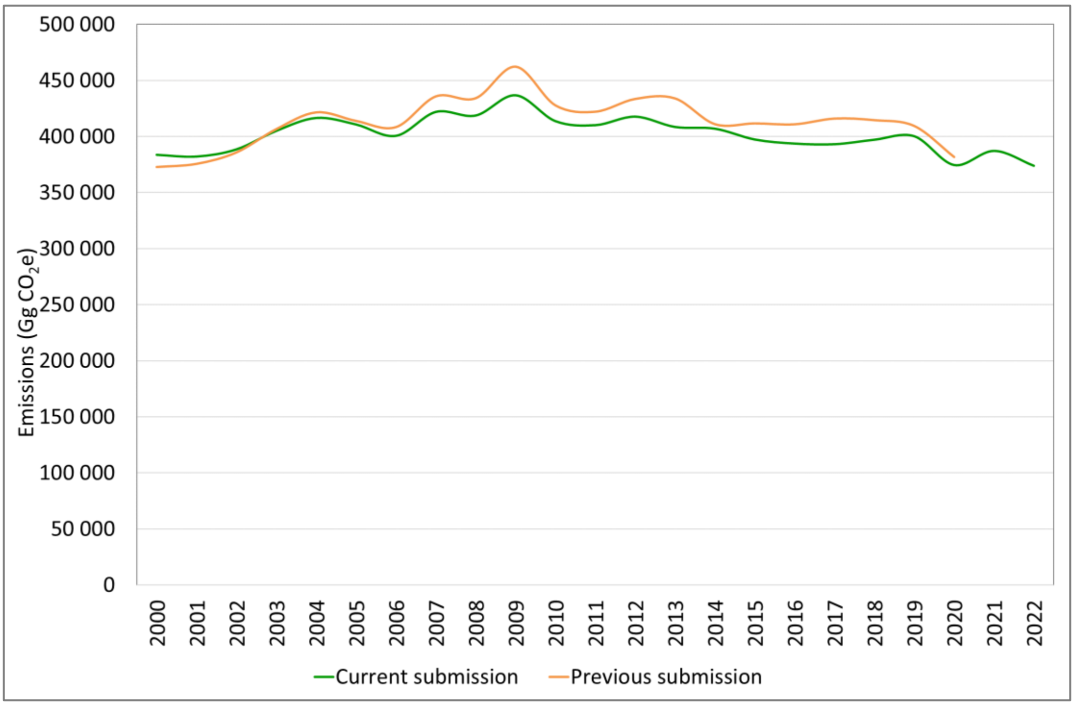

Figure 1.13: Recalculations for the Energy sector between 2000 and 2022.

1.15.1.4 Planned improvements

Improvements planned for the Energy sector are as follows:

- Moving to country-specific CO_2 factors for key solid fuels. A study was initiated in 2023 to determine the country-specific carbon contents, NCVs and emission factors for commonly used solid fuels.
- Improving activity data for fuel wood consumption in different sub-sectors.
- Including emissions from abandoned mines and spontaneous combustion.

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[1] *This only affects categories 1A4 and 1A5*

- Disaggregating the uncertainty assessment to align with the disaggregation used for key category analysis.

1.15.2 IPPU

The IPPU sector includes non-energy related emissions from industrial processing plants. The main emission sources are released from industrial processes that chemically or physically transform raw materials and thereby release GHGs, (e.g., ammonia products manufactured from fossil fuels), GHG emissions released during these processes are CO_2, CH_4, N_2O, HFCs, PFCs and SF_6.

The following industrial processes are included in the estimation of emissions from South Africa's IPPU sector:

Cement Production	*Hydrogen Production*
Lime Production	*Other Chemicals*
Glass Production	*Production of steel from iron and scrap steel*
Other Product Uses of Carbonates	*Ferroalloys Production*
Ammonia Production	*Aluminium Production*
Nitric Acid Production	*Lead Production*
Carbide Production	*Zinc Production*
Titanium Dioxide Production	*Vanadium Production*
Soda Ash Production	*Lubricant Use*
Petrochemical and carbon black production	*Paraffin Wax Use*
Product Uses as Substitutes for Ozone Depleting **Substances**	

HFCs and PFCs are used in many products and in refrigeration and air conditioning equipment. PFCs are also emitted because of anode effects in aluminium smelting. Therefore, the IPPU sector includes estimates of PFCs from aluminium production, and HFCs from refrigeration and air conditioning. SF_6 is also included in IPPU due to the use of electrical equipment.

The estimation of GHG emissions from non-energy sources is often difficult because they are widespread and diverse. The difficulties in the allocation of GHG emissions between fuel combustion and industrial processes arise when by-product fuels or waste gases are transferred from the manufacturing site and combusted elsewhere in different activities.

The performance of the economy is the key driver for trends in the IPPU sector. The South African economy is directly related to the global economy, mainly through exports and imports. South Africa officially entered an economic recession in May 2009, which was the first in 17 years. Until the global economic recession affected South Africa in late 2008, economic growth had been stable and consistent.

As a result of the recession, GHG emissions during that period decreased across almost all categories in the IPPU sector. Since then, GDP annual growth has slowed compared to growth before the recession. The Covid 19 pandemic caused economic growth to decline during 2020, especially during the second half of the year when lockdown measures where stricter. During 2021 and 2022 economic growth recovered to pre-covid figures.

During 2022 South Africa moved away from Tier 1 reporting towards Tier 2 and Tier 3 calculations. In certain sectors, this made quite a difference. The Metal Industry was affected most, but the accuracy has improved. The 2023 Verification programme also enhanced accuracy of Tier 3 reporting. Due to these changes, comparison with historical figures is compromised in the short term.

The largest source of emissions in the IPPU sector in South Africa is the production of ferroalloys, iron and steel followed by cement production.

1.15.2.1 Trends

In 2022 the IPPU sector produced 30 598 Gg CO_2e which is 6.4% of South Africa's emission (excl. LULUCF). The IPPU sector produces CO_2 emissions (78.4%), fluorinated gases (20.0%) and smaller amounts of CH_4 (0.4%) and N_2O (1.2%) (Table 1.9). Carbon dioxide and any other emissions from combustion of fuels in these industries are reported under the Energy sector. The largest source category is the

Metal industry category. which contributes 51.2% to the total IPPU sector emissions. The *Mineral industry* and the *Product used as substitutes for ozone depleting substances* subsectors contribute 19.8% and 19.4%, respectively, to the IPPU sector emissions. *Iron and steel production* and *Ferroalloys production* are the biggest CO_2 contributors to the *Metal industry* subsector, producing 6 307 Gg CO_2 (40.3%) and 8 081 Gg CO_2 (51.6%) respectively to the total metal industry GHG emissions.

Table 1.9: Summary of the estimated emissions from the IPPU sector in 2022 for South Africa.

GHG source categories	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	Gg CO_2e						
2.IPPU	**23 976**	**121**	**364**	**5 945**	**126**	**66**	**30 598**
2.A Mineral industry	6 055	NA	NA	NA	NA	NA	6 055
2.B Chemical industry	1 268	121	364	NA	NA	NA	1 753
2.C Metal industry	15 529	NE	NA	NA	126	NA	15 655
2.D Non-energy products from fuels and solvents	1 125	NA	NA	NA	NA	NA	1 125
2.E Electronic industry	NE	NE	NE	NE	NE	NA	NE
2.F Product uses as substitute ODS	NA	NA	NA	5 945	NE	NA	5 945
2.G Other product manufacture and use	NE	NE	NE	NE	NE	66	66
2.H Other	NE	NE	NE	NE	NE	66	NE

Even though the South African economy recovered after the COVID-19 pandemic, estimated emissions from the IPPU sector are 2 183 Gg CO_2e (-6.7%) lower than the emissions in 2000 (

Table 1.10). The decline can be attributed to the decline in metals production (-39.0%), specifically *Iron and Steel production* and *Aluminium production*. This can be ascribed to a decrease in global demand. The decline in the chemicals industry also made a huge difference (-31.4%). *Cement production* and *Non-energy product use from fuels and solvents* increased emissions from 2000 by 2 081 Gg CO_2e. The local demand for cement increased dramatically from 2000.

Table 1.10 shows that IPPU emissions increased by 18.0% between 2000 and 2006, after which there was a 13.6% decline to 2009. This decrease was mainly due to the global economic recession and the electricity crisis that occurred in South Africa during this period. From 2010 emissions increased due to an increase in the *metal industry* and *products used as substitutes for ozone depleting substances* subsectors. The economy was also beginning to recover from the global recession.

Emissions decreased from 2016 as demand for South African chemical and metals dropped. COVID-19 also had a major local and international impact between 2020 and 2021.

Table 1.10: Summary of the change in emissions from the IPPU sector between 2000 and 2022

GHG source categories	Emissions ($Gg\ CO_2e$)			Difference ($Gg\ CO_2e$)		Change (%)	
	2000	2020	2022	2000-2022	2020-2022	2000-2022	2020-2022
2.IPPU	**32 781**	**24 858**	**30 598**	**-2 183**	**5 740**	**-6,7**	**23,1**
2.A Mineral industry	**4 371**	**4 774**	**6 055**	**1 684**	**1 281**	**38,5**	**26,8**
2A1 Cement Production	3 871	3 796	5 023	1 152	1 227	29,8	32,3
2A2 Lime Production	426	715	694	268	-21	62,8	-3,0
2A3 Glass Production	74	154	191	117	37	157,5	23,9
2A4 Other Process Uses of Carbonates	NE	109	147		38		34,7
2.B Chemical industry	**2 557**	**2 247**	**1 753**	**-804**	**-494**	**-31,4**	**-22,0**

GHG source categories	Emissions (Gg CO_2e)			Difference (Gg CO_2e)		Change (%)	
	2000	2020	2022	2000-2022	2020-2022	2000-2022	2020-2022
2B1 Ammonia Production	C	C	C				
2B2 Nitric Acid Production	C	C	C				
2B5 Carbide Production	C	C	C				
2B6 Titanium Production	C	C	C				
2B7 Soda Ash Production	NE	C	C				
2B8f Petrochemical and Black Carbon Production	C	C	C				
2B8g Hydrogen Production	NE	C	C				
2B10 Other	NE	C	C				
2.C Metal industry	**25 658**	**12 391**	**15 655**	**-10 003**	**3 263**	**-39,0**	**26,3**
2C1 Iron and Steel Production	15 334	3 854	6 307	-9 027	2 453	-58,9	63,6
2C2 Ferroalloy Production	8 084	7 233	8 081	-3	848	0,0	11,7
2C3 Aluminium Production	2 116	1 261	1 259	-857	-2	-40,5	-0,1
2C5 Lead Production	15	7	7	-8	1	-52,4	9,0
2C6 Zinc Production	108	37	0	-108	-37	-100,0	-100,0
2.D Non-energy products from fuels and solvents	**196**	**84**	**1 125**	**929**	**1 041**	**474,1**	**1 245,5**
2D1 Lubricant Use	189	82	516	327	434	173,6	527,5
2D2 Paraffin Wax Use	7	1	609	602	608	8 091,2	43 042,8
2.E Electronic industry	NE	NE	NE				
2.F Product uses	NE	**5 284**	**5 945**	**5 945**	**661**		**12,5**

GHG source categories	Emissions ($Gg CO_2e$)			Difference ($Gg CO_2e$)		Change (%)	
	2000	2020	2022	2000-2022	2020-2022	2000-2022	2020-2022
as substitute ODS							
2F1 Refrigeration and Air Conditioning	NE	5 187	5 837		650		12,5
2F2 Foam Blowing Agents	NE	2	2		0		0,0
2F3 Fire Protection	NE	76	88		11		15,0
2F4 Aerosols	NE	18	18		0		0,0
2.G Other product manufacture and use	NE	**78**	**66**	**66**	**-12**		**-15,5**
2.H Other	NE	NE	NE				

1.15.2.2 Methods and data

A summary of the methods and emission factors applied to each subsector of IPPU is shown in Table 1.11 below.

Table 1.11: Summary of methods and emission factors for the IPPU sector and an assessment of the completeness of the IPPU sector emissions

GHG Source and sink category		CO_2		CH_4		N_2O		HFCs		PFCs		SF6		NOx	CO	NMVOC	SO_2
		Method	Emissio	Method	Emissio	Method	Emissio	Method applied	Emissio	Method	Emissio	Method	Emissio				
A	**Mineral industry**																
1	*Cement production*	T2	CS	NE										NE	NE	NE	NE
2	*Lime production*	T3	CS	NE										NE	NE	NE	NE
3	*Glass production*	T3	CS	NE										NE	NE	NE	NE
4	*Other process uses of carbonates*	T3	CS	NE										NE	NE	NE	NE
B	**Chemical industry**																
1	*Ammonia production*	T3	CS	T3	CS	NE								NE	NE	NE	NE
2	*Nitric acid production*	NE		NE		T3	CS							NE	NE	NE	NE

	GHG Source and sink category	CO_2 Method applied	CO_2 Emission factor	CH_4 Method applied	CH_4 Emission factor	N_2O Method applied	N_2O Emission factor	HFCs Method applied	HFCs Emission factor	PFCs Method applied	PFCs Emission factor	SF6 Method applied	SF6 Emission factor	NOx	CO	NMVOC	SO_2
3	*Adipic acid production*	NO		NO		NO								NO	NO	NO	NO
4	*Caprolactam, glyoxal and glyoxylic acid production*	NO		NO		NO								NO	NO	NO	NO
5	*Carbide production*	T3	CS	T1	DF	NE								NE	NE	NE	NE
6	*Titanium dioxide production*	T3	CS	NE		NE								NE	NE	NE	NE
7	*Soda Ash production*	T3	CS	NE		NE								NE	NE	NE	NE
8a	*Methanol*	NO		NO		NO								NO	NO	NO	NO
8b	*Ethylene*	NO		NO		NO								NO	NO	NO	NO

GHG Source and sink category		CO2		CH4		N2O		HFCs		PFCs		SF6		NOx	CO	NMVOC	SO2
		Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor				
8c	*Ethylene Dichloride and Vinyl Chloride Monomer*	NO		NO		NO								NO	NO	NO	NO
8d	*Ethylene Oxide*	NO		NO		NO								NO	NO	NO	NO
8e	*Acrylontrile*	NO		NO		NO								NO	NO	NO	NO
8f	*Petrochemical and carbon black production*	T1	DF	T1	DF	NE								NE	NE	NE	NE
8g	*Hydrogen Production*	T3	CS	NE		NE								NE	NE	NE	NE
9	*Fluorochemical production*							NO		NO		NO		NO	NO	NO	NO
11	*Other*	T2	CS	T2	CS	NE		NE		NE		NE		NE	NE	NE	NE

GHG Source and sink category		CO_2		CH_4		N_2O		HFCs		PFCs		SF6		NOx	CO	NMVOC	SO_2
		Method	Emissio	Method	Emissio	Method	Emissio	Method applied	Emissio	Method	Emissio	Method	Emissio				
C	**Metal industry**																
1	*Iron and steel production*	T3	CS	NE		NE								NE	NE	NE	NE
2	*Ferroalloy production*	T3	CS	T3	CS	NE								NE	NE	NE	NE
3	*Aluminium production*	T3	CS	NE						T3	CS			NE	NE	NE	NE
4	*Magnesium production*	NO						NO		NO		NO		NO	NO	NO	NO
5	*Lead production*	T1	DF											NE	NE	NE	NE
6	*Zinc production*	T1	DF											NE	NE	NE	NE
D	**Non-energy products from fuels and solvents**																

GHG Source and sink category		CO₂		CH₄		N₂O		HFCs		PFCs		SF6		NOx	CO	NMVOC	SO₂
		Method	Emissio	Method	Emissio	Method	Emissio	Method applied	Emissio	Method	Emissio	Method	Emissio				
1	*Lubricant use*	T1	DF											NE	NE	NE	NE
2	*Paraffin wax use*	T1	DF	NE		NE								NE	NE	NE	NE
3	*Solvent use*													NE	NE	NE	NE
E	**Electronics industry**																
1	*Integrated circuit or semiconductor*	NE				NE		NE		NE		NE		NE	NE	NE	NE
2	*TFT flat panel display*							NE		NE		NE		NE	NE	NE	NE
3	*Photovoltaics*							NE		NE		NE		NE	NE	NE	NE
4	*Heat transfer fluid*													NE	NE	NE	NE
F	**Product uses as substitute ODS**																

GHG Source and sink category		CO_2		CH_4		N_2O		HFCs		PFCs		SF6		NOx	CO	NMVOC	SO_2
		Method	Emissio	Method	Emissio	Method	Emissio	Method applied	Emissio	Method	Emissio	Method	Emissio				
1	*Refrigeration and air conditioning*	NE						T2a, T2b	DF	NE				NE	NE	NE	NE
2	*Foam blowing agents*	NE						T1	DF	NE				NE	NE	NE	NE
3	*Fire protection*	NE						T1	DF	NE				NE	NE	NE	NE
4	*Aerosols*							T1a, T2a	DF	NE				NE	NE	NE	NE
5	*Solvents*							NE		NE				NE	NE	NE	NE
G	**Other product manufacture and use**																
1	*Electrical equipment*									NE		NE		NE	NE	NE	NE
2	*SF6 and PFCs from other product uses*									NE		NE		NE	NE	NE	NE

GHG Source and sink category		CO_2		CH_4		N_2O		HFCs		PFCs		SF6		NOx	CO	NMVOC	SO_2
		Method	Emissio	Method	Emissio	Method	Emissio	Method applied	Emissio	Method	Emissio	Method	Emissio				
3	*N_2O from product uses*					NE								NE	NE	NE	NE
H	**Other**																
1	*Pulp and paper industry*	NE		NE										NE	NE	NE	NE
2	*Food and beverage industry*	NE		NE										NE	NE	NE	NE

1.15.2.3 Recalculations

Through the introduction of the NGER in 2017 (DEA, 2017a), amendments to these regulation in 2020 (DEFF, 2020) as well as the introduction of the SAGERS, the GHG reporting tool, there have been various additions to the inventory as well as recalculations up to 2020. During 2020 a major change was the introduction of Tier 2 and Tier 3 calculation methods as far as possible. This did lead to improved accuracy of the inventory. An external verification process was launched for key emission contributors which increased the level of accuracy. The accuracy improvement has not been quantified.

No categories were added from 2020.

1.15.3 Agriculture

1.15.3.1 Trends

In 2022 the Agriculture sector produced 53 519 Gg CO_2e which is 11% of South Africa's total emissions. The largest source category in 2022 is Enteric fermentation caegory which contributed 36 352 Gg CO_2e, 68% to the total agricultural sector emissions. Overall decreasing trend, the total emissions were 9% lower in 2022 compared to 2000 levels, this is due to decrease in livestock population numbers (Figure 1.14).

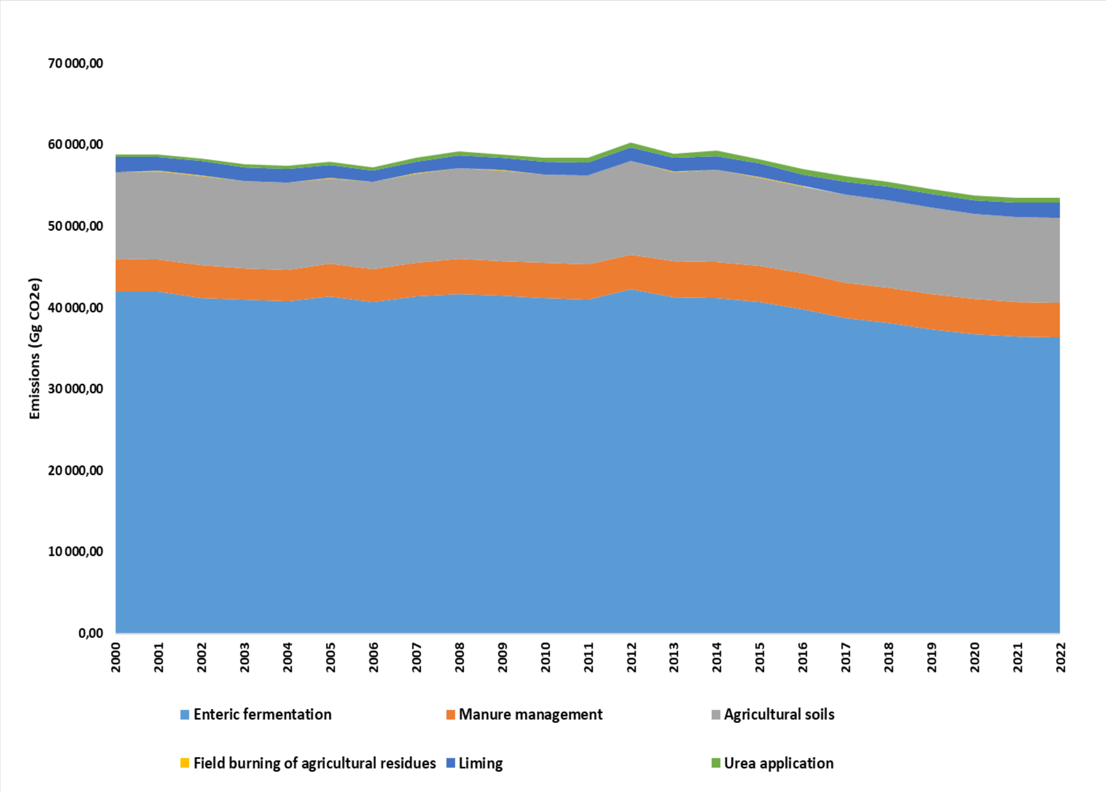

Figure 1.14: The overall AFOLU emissions for South Africa between 2000 – 2022

GHG emissions and removals from Agriculture sector are reported separately. The main categories included in the emission estimates for the agriculture sector are shown in Table 1.12. These are based on the IPCC 2006 Guidelines.

Table 1.12: List of IPCC categories included in AFOLU sector emissions inventory

IPCC Category	Category name	Included
3A	Enteric fermentation	√
3B	Manure management	√
3C	Rice cultivation	NO
3D1	Direct N_2O emissions from managed soils	√
3D2	Indirect N_2O from managed soils	√
3E	Prescribed burning of savannahs	IE
3F	Field burning of agricultural residues	√
3G	Liming	√
3H	Urea application	√
3I	Other carbon containing fertilisers	NE

Livestock included are dairy cattle, other cattle, sheep, goats, horses, mules and asses, swine and poultry. Emissions from ruminants in privately owned game parks were excluded due to comments made during the UNFCCC review.

Rice cultivation is not included. Food and Agriculture Organization (FAO) statistics indicate that there is a small area of rice cultivation in South Africa and therefore in the UNFCCC review it was indicated that this should be investigated and included if necessary. Discussions with various experts at the ARC suggests that there have been some small experimental plots for rice cultivation, but the precise area was not known but it is thought to be less than 50 ha. For this reason, rice cultivation is considered insignificant.

Emissions from fuel combustion in this sector are not included here as these falls under Transport (category 1A4c *Agriculture/forestry/fisheries*) in the Energy sector subsector.

1.15.3.2 Methods and data

The IPCC 2006 methodology (IPCC, 2006) is applied in this sector, with a few updated methodologies being taken from the IPCC 2019 Refinement of the 2006 Guidelines (IPCC, 2019). Default constants and emission factors are also sourced from these two guideline documents, with details being provided in the methodology sections within each category section. Table 1.13 shows the methods and types of emission factors used in the Agriculture inventory.

Table 1.13: Summary of methods and emission factors for the Agriculture sector and an assessment of the completeness of the Agriculture sector emissions.

	GHG Source and sink category	CO_2		CH_4		N_2O		NO_x	CO	NMVOC	NH_3
		Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor				
3A LIVESTOCK	***3.A Enteric fermentation***										
	3.A.1- Cattle										
	3.A.1.a - Dairy cows	NA	NA	T2	CS	NA	NA	NA	NA	NA	NA
	3.A.1.b - Other cattle	NA	NA	T2	CS	NA	NA	NA	NA	NA	NA
	3.A.2 - Sheep	NA	NA	T2	CS	NA	NA	NA	NA	NA	NA
	3.A.3 - Swine	NA	NA	T2	CS	NA	NA	NA	NA	NA	NA
	3.A.4 - Other										
	3.A.4.a - Buffalo	NA	NA	NO	NO	NA	NA	NA	NA	NA	NA
	3.A.4.b - Camels	NA	NA	NO	NO	NA	NA	NA	NA	NA	NA
	3.A.4.d - Goats	NA	NA	T2	CS	NA	NA	NA	NA	NA	NA
	3.A.4.e - Horses	NA	NA	T1	DF	NA	NA	NA	NA	NA	NA
	3.A.4.f – Mules and Asses	NA	NA	T1	DF	NA	NA	NA	NA	NA	NA
	3.B Manure management										
	3.B.1- Cattle										
	3.B.1.a - Dairy cows	NA	NA	T2	CS	T2	DF	NE	NA	NA	NE
	3.B.1.b - Other cattle	NA	NA	T2	CS	T2	DF	NE	NA	NA	NE
	3.B.2 - Sheep	NA	NA	T2	CS	NO	NO	NE	NA	NA	NE
	3.B.3 - Swine	NA	NA	T2	CS	T2	DF	NE	NA	NA	NE
	3.B.4 - Other										
	3.B.4.a - Buffalo	NA	NA	NO	NO	NO	NO	NE	NA	NA	NE
	3.B.4.b - Camels	NA	NA	NO	NO	NO	NO	NE	NA	NA	NE
	3.B.4.d - Goats	NA	NA	T2	CS	NO	NO	NE	NA	NA	NE

GHG Source and sink category		CO_2		CH_4		N_2O		NO_x	CO	NMVOC	NH_3
		Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor				
	3.B.4.e - Horses	NA	NA	T2	CS	NO	NO	NE	NA	NA	NE
	3.B.4.f – Mules and Asses	NA	NA	T2	CS	NO	NO	NE	NA	NA	NE
	3.B.4.g - Poultry	NA	NA	T2	CS	T2	DF	NE	NA	NA	NE
	3.B.5-Indirect N_2O emissions										
	3.C – Rice cultivation	NO		NO		NO					
	3.D –Agricultural soils										
	3.D.1 – Direct N_2O Emissions from managed soils										
	Synthetic fertilizers	NA		NA		T1	DF		NA	NA	
	Animal waste added to soils	NA		NA		T1	DF		NA	NA	
	Other organic fertilizers	NA		NA		T1	DF		NA	NA	
	Urine and dung deposited by grazing livestock	NA		NA		T1	DF		NA	NA	
	Crop residues	NA		NA		T1	DF		NA	NA	
	3.D.2 – Indirect N_2O Emissions from managed soils										
	Atmospheric deposition	NA		NA		T1	DF				
	Nitrogen leaching and runoff	NA		NA		T1	DF				
	3.E – Prescribed burning of savannas										
	Prescribed burning of savannas	NE		NE		NE					
	3.F – Field burning of Agricultural residues										

GHG Source and sink category		CO_2 Method applied	CO_2 Emission factor	CH_4 Method applied	CH_4 Emission factor	N_2O Method applied	N_2O Emission factor	NO_x	CO	NMVOC	NH_3
	Field burning of Agricultural residues	T2	DF, CS	T2	DF, CS	T2	DF, CS				
	3.G - Liming										
	Liming	T1	DF	NA		NA		NA	NA	NA	NA
	3. H - Urea application										
	Urea application	T1	DF	NA		NA		NA	NA	NA	NA
	3.I – Other carbon containing fertilisers										
	Other carbon containing fertilisers	NE		NE		NE					
	3.J - Other										
	Other	NE		NE		NE					

1.15.3.3 Recalculations

Agriculture and LULUCF were split into separate chapters within the NIR. All the other land category (*Forest land, Grassland, Wetland and Settlement*) non-CO_2 biomass burning emissions were removed from agriculture sector and incorporated into the LULUCF sector. The agricultural burning emissions, which in this inventory were assumed to be emissions from pre-harvest burning of sugarcane, were incorporated into category 3F (*Field burning of agricultural residues*).

The AFOLU sector undergoes ongoing enhancements that result in recalculations and substantial modifications have been made to this sector. The improvements and their impact on the total changes in the 2022 estimates are detailed below (Figure 1.15). The recalculations for the Agriculture sector led to an increase of 20% increase in the estimates over the times series. The recalculations resulted in a 20% increase in the 2022 estimates for agriculture, primarily attributed to significant improvements.

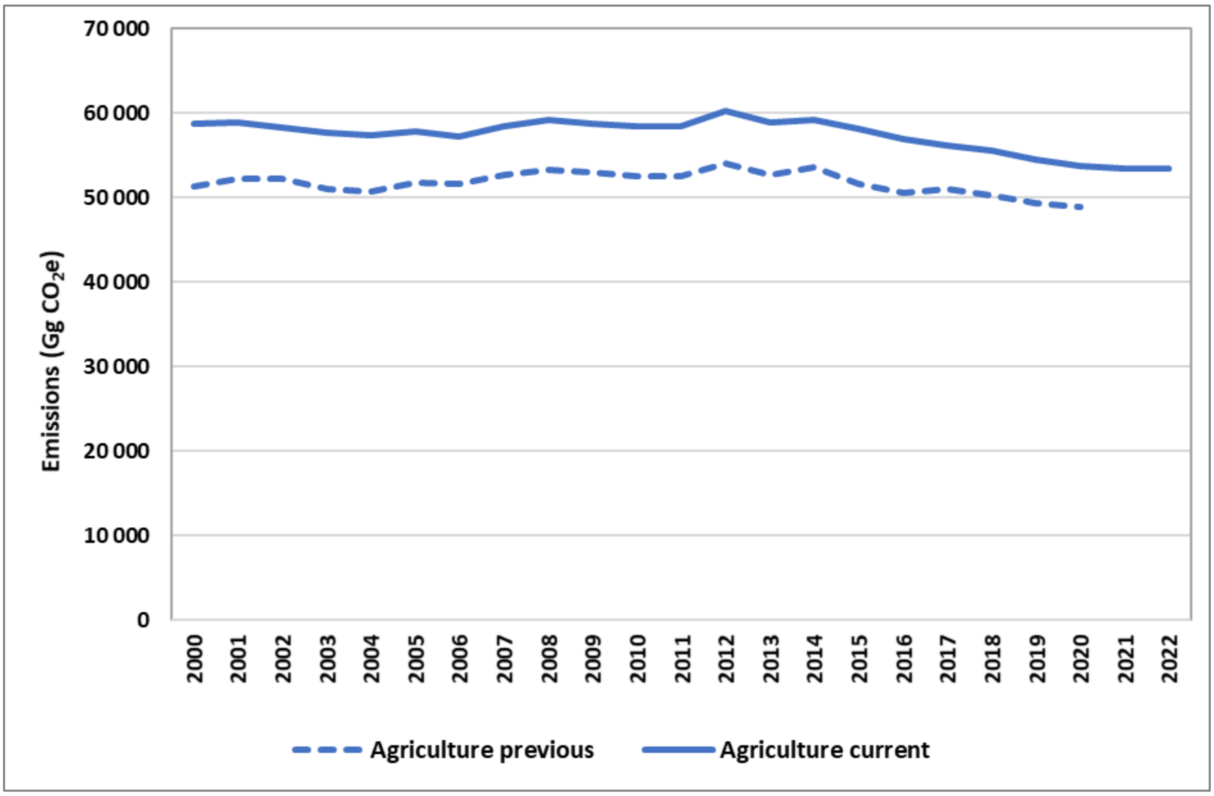

Figure 1.15: Change in Agriculture emission estimates due to recalculations since 2020 submission.

In addition, the weighting is applied to the emission factors and not to the population data as was done in the previous inventory. Emissions were therefore recalculated for the entire time series and led to a 59.1% increase (79.8% for manure CH_4 emissions) in emissions compared to the previous inventory. The calculation of lime application emissions per crop type was based on crop area data and application rates. This involved utilizing crop area estimates in combined with application rates sourced from Tongwane et al. (2016). However, this approach resulted in an estimate exceeding 3 million tons of lime in 2008, in contrast to the 1.5 million tons reported by the Fertiliser Association of South Africa.

1.15.3.4 Planned improvements

Planned improvements and recommendations are given in Table 1.14 below. These will be prioritised as required and are dependent on resources.

Table 1.14: Planned improvements and recommendations

IPCC Code	Improvement / Recommendation
General	• Have sector specific engagements discussing the expectations regarding moving to the higher Tier methods. • Address time series consistency issues as data becomes available for specific categories that have been newly included in the inventory. • Ensure that facility intensity data is available (even though not publicly). • Expand reporting to have sector and technology specific intensities.
2A1	• Investigate historical data for the imports and exports of clinker
2A2	• Undertake a completeness assessment to determine if non-marketed lime is reported
2A3	• Disaggregate the cullet ratio by facility.
2B6	• Investigate the availability of the historical data.
2C5	• Investigate the air quality database for those data providers that trigger reporting under Lead Battery processing
2C6	• 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.

IPCC Code	Improvement / Recommendation
2D1	• South Africa to undertake a desktop study regarding two-stroke engines and the use of blended lubricant.
2D	• Investigate the availability of more accurate data
2F	• Investigate the availability of more accurate data

1.15.4 Land use, Forestry and Land Use Change (LULUCF)

In the previous NIR the LULUCF sector was referred to as the FOLU sector (Forestry and Other Land Use) and it formed part of the AFOLU (Agriculture, Forestry and Other Land Use) sector. In the 2022 NIR the Agriculture and LULUCF sectors have been separated to bring the inventory into alignments with the Common Reporting Table (CRT) reporting requirements under the Enhanced Transparency Framework (ETF). In the LULUCF sector South Africa reports on the emissions (positive) and removals (negative) of CO_2 from the following carbon pools:

Above-ground biomass:

- Includes all living biomass above the soil including stem, stump, branches, bark, seeds, and foliage.
- Included for all land categories.

Below-ground biomass:

- Includes all biomass of live roots.
- Included for all land categories.

Litter:

- Included all non-living biomass, lying dead, in various states of decomposition above the mineral or organic soil.

Included for all land categories.

Dead wood:

- Includes all non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil.
- Only included for the Forest land category.

Mineral soils:

- Includes organic carbon in mineral soils to a depth of 30cm.
- Included for all land categories.

Harvested wood products (4.G.).

Organic soils were assumed to be negligible (Moeletsi et al., 2015).

The carbon pools are reported for the following land-use categories:

- *Forest land* (4.A.)
- *Cropland* (4.B.)
- *Grassland* (4.C.)
- *Wetlands* (4.D.)
- *Settlements* (4.E.)
- *Other land* (4.F.)

As well as the relevant land-use changes between these categories. A distinction is made between areas which, during the reporting period:

- undergo no land-use changes, and thus remain, in unchanged form, in the land-use category they are in ("land remaining" categories 4.A.1 – 4.F.1)
- undergo land-use changes: From the time of conversion onward, these areas are reported in the category to which they were converted. Within those land-use categories, the converted areas are then reported in conversion categories ("land conversion" categories 4.A.2 – 4.F.2) for a total of 20 years. After 20 years in a conversion category, the areas are reported under the relevant remaining categories.

Wetlands also include the emissions of CH_4 and N_2O and non-CO_2 gases emitted from biomass burning are included for *Forest land*, *Grassland*, *Wetlands*, and *Settlements*. In *Croplands* the burning is due to pre-harvest burning of sugarcane and this is included under Agriculture in category 3.F. Other lands are assumed not to burn due to the absence of biomass. Emissions from humus mineralisation in mineral soils as a result of land use change and/or land management are reported in the Agriculture sector under category 3.D.1.

The reporting of non-CO_2 emissions from biomass burning was incorporated into the Agriculture component of the AFOLU sector in the previous inventory (under the *Aggregated and non-CO_2 emissions* category (3.C)), however due to the adjusted reporting requirements these non-CO_2 emissions are now included within each land use category under the LULUCF sector.

1.15.4.1 Trends

The LULUCF sector was a sink in 2022 (Table 1.15) with *Forest lands* being the largest contributor to the sink. All other land categories were a source of emissions in 2022, with *Other lands* being the largest.

Table 1.15: Summary of emissions from the LULUCF sector in 2022.

Greenhouse gas source and sink categories	CO_2	CH_4		N_2O		Total
	Gg CO_2	Gg	Gg CO_2e	Gg	Gg CO_2eq	Gg CO_2e
4. LULUCF	**-56 146.3**		**11 019.8**		**2 066.7**	**-43 059.8**
4.A. Forest land	-90 082.4	57.7	1 614.3	3.4	**909.3**	-87 558.8
4.B. Cropland	3 508.9	IE	IE	IE	IE	3 508.9
4.C. Grassland	10 576.8	25.2	705.87	2.3	610.65	11 893.4
4.D. Wetlands	748.0	310.6	8 697.0	2.1	544.4	9 989.3
4.E. Settlements	258.5	0.1	2.7	0.01	2.4	263.6
4.F. Other land	19 025.4	NA	NA	NA	NA	19 025.4
4.G. Harvested wood products	-181.4	NA	NA	NA	NA	-181.4

Figure 1.16 provides an overview of the LULUCF emission trends for South Africa over the time-series 2000-2022. The time-series reflects the trends in land-use changes. The land-use changes have been determined based on South African National Land Cover (SANLC) data sets for the reference years 1990, 2014, 2018 and 2020. Between the reference years, the land-use changes have been linearly interpolated, hence the larger changes after each refence year and the constant average land-use changes between reference periods. A map is being developed for 2022 but was not finalised before the preparation of this inventory and so the data was not included in this inventory. Data for the period 2020-2022 was extrapolated based on the change area provided between 2018 and 2020.

Forest lands were the largest contributor to the sink across the time-series. The dominant *Forest land* sinks were thickets and woodlands. The increasing *Forest land* sink between 2014 and 2022 is due to an increasing woodland sink because of an increase in the conversion of grassland to woodland. The increasing woodland sink was reduced slightly between 2017 and 2022 by the decreasing thicket sink caused by a reduction in the thicket area. The overall variation in the *Forest land* category follows a similar pattern to the burnt area data. For example, the years 2005 and 2021 were high burn years which meant an increase in emissions and an increase in disturbance losses in *Forest lands* therefore a reduced sink in 2005 and 2021.

Croplands showed an increase in emissions between 2015 and 2018 due to the conversion of perennial crops to annual crops and the conversion of woodlands to subsistence crops. These emissions were reduced between 2019 and 2022 as these conversions were reduced and there was some conversion of annual crops to perennial crops.

The change in *Grasslands* is what was causing the reduced sink between 2017 and 2022. Between 2015 and 2018 there is an increase in the conversion of low shrublands to grasslands, while between 2019 and 2022 there is an increase in the conversion of woodland to grassland leading to an increased source.

Converted lands were the largest contributors to all land categories except *Wetlands* where non-CO_2 emissions from wetlands play a role. Overall, the LULUCF sector increased its sink by 56.3% since 2000 and by 17.9% since 2020. *Grasslands* changed from a small sink in 2000 to a large source in 2020 and 2022. Changes were large between 2000 and 2020 with part of the reason being that the data for these years came from two different land change maps, however change is small between 2020 and 2022 as would be expected from a shorter change period and where the comparison is between two maps produced in the same way.

Biomass is the dominant carbon pool. Soils remain a small sink throughout the time-series, while The DOM pool increases its sink strength between 2019 and 2022.

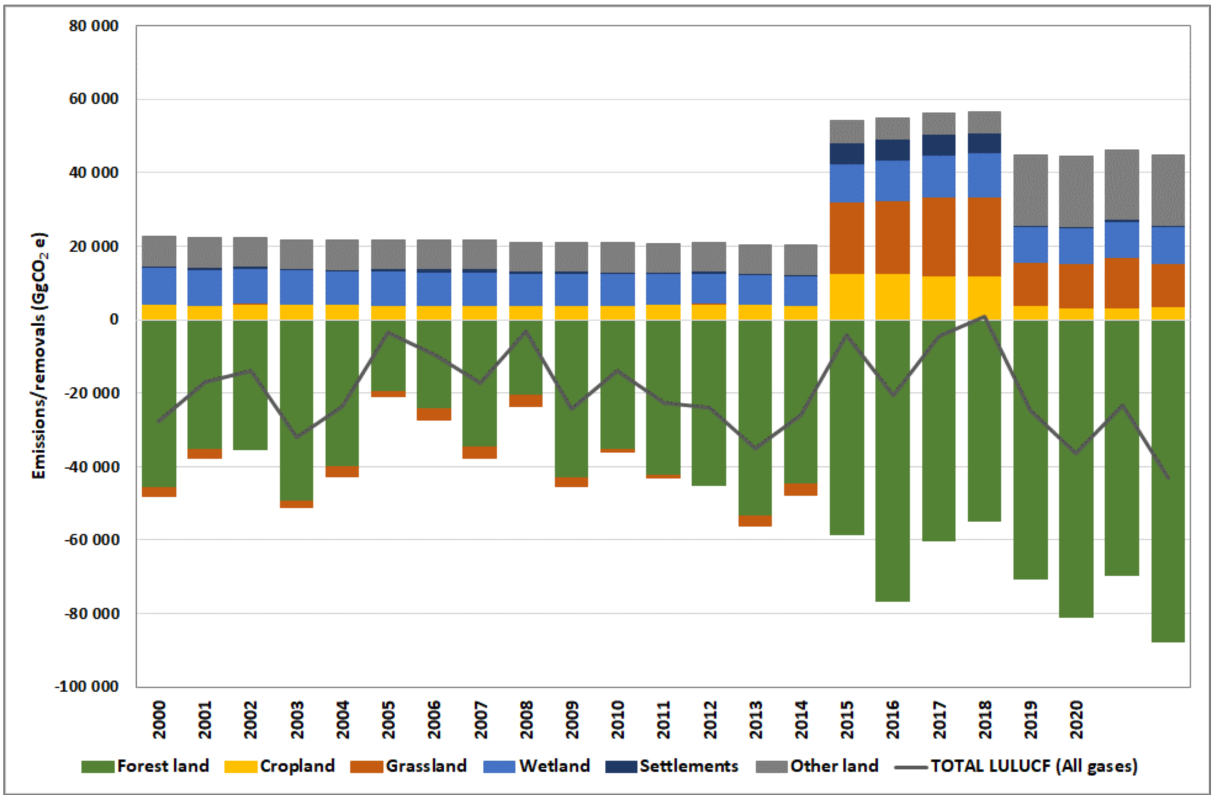

Figure 1.16: Time series for GHG emissions and removals by land type in the LULUCF sector in South Africa, 2000 - 2022.

1.15.4.2 Methods and data

A summary of the tier level of the methods and types of emission factors incorporated into the inventory are provided in Table 1.16.

Table 1.16: Summary of methods and emission factors for the LULUCF sector and an assessment of the completeness of the sector.

GHG Source and sink category	CO_2 Method applied	CO_2 Emission factor	CH_4 Method applied	CH_4 Emission factor	N_2O Method applied	N_2O Emission factor	NO_x	CO	NMVOC	NH_3
4A Forest land										
4.A.1. Forest land remaining forest land	Biomass: T2	Biomass: CS	T1	DF	T1	DF	T1/DF	T1/DF	T1/DF	NE
	Litter: T2	Litter: CS								
	Soil: T2	Soil: CS								
4.A.2. Land converted to forest land	Biomass: T2	Biomass: CS	IE	DF	IE	DF	T1/DF	T1/DF	T1/DF	NE
	Litter: T2	Litter: CS								
	Soil: T2	Soil: CS								
4B Cropland										
4.B.1. Cropland remaining cropland	Biomass: T1 (annuals), T2 (perennials)	Biomass: DF/CS	IE		IE		IE	IE	IE	NE
	Litter: T1/T2	Litter: DF/CS								
	Soil: T2	Soil: CS								
4.B.2. Land converted to cropland	Biomass: T2	Biomass: CS	IE		IE		IE	IE	IE	NE
	Litter: T2	Litter: CS								
	Soil: T2	Soil: CS								
4C Grassland										
4.C.1. Grassland remaining grassland	Biomass: T1 (grasslands), T2 (low shrubland)	Biomass: DF/CS	T1	DF	T1	DF	T1/DF	T1/DF	T1/DF	NE

GHG Source and sink category	CO_2		CH_4		N_2O		NO_x	CO	NMVOC	NH_3
	Method applied	**Emission factor**	**Method applied**	**Emission factor**	**Method applied**	**Emission factor**				
	Litter: T1/T2	Litter: DF/CS								
	Soil: T2	Soil: CS								
4.C.2. Land converted to grassland	Biomass: T2	Biomass: CS	T1	DF	T1	DF	T1/DF	T1/DF	T1/DF	NE
	Litter: T2	Litter: CS								
	Soil: T2	Soil: CS								
4D Wetland										
4.D.1. Wetland remaining wetland	Biomass: T1/T2 Litter: T1/T2 Soils: T2	Biomass: DF/CS Litter: DF/CS Soil: CS	T1	DF/CS	T1	DF/CS	T1/DF	T1/DF	T1/DF	NE
4.D.2. Land converted to wetland	Biomass: T2 Litter: T2 Soil: T2	Biomass: CS Litter: CS Soil: CS	T1	DF	T1	DF	T1/DF	T1/DF	T1/DF	NE
4E Settlements										
4.E.1. Settlements remaining settlements	Biomass: T2	Biomass: CS	T1	DF	T1	DF	T1/DF	T1/DF	T1/DF	NE
	Litter: T2	Litter: CS								
	Soil: T2	Soil: CS								
4.E.2. Land converted to settlements	Biomass: T2	Biomass: CS	T1	DF	T1	DF	T1/DF	T1/DF	T1/DF	NE
	DOM: T2	Litter: CS								
	Soil: T2	Soil: CS								
4F Other land										

GHG Source and sink category	CO_2		CH_4		N_2O		NO_x	CO	NMVOC	NH_3
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor				
4.F.1. Other land remaining other land	Biomass: NA		NA		NA		NA	NA	NA	NA
	Litter: NA									
	Soil: T2	Soil: CS								
4.F.2. Land converted to other land	Biomass: T2	Biomass: CS	NA		NA		NA	NA	NA	NA
	Litter: T2	Litter: CS								
	Soil: T2	Soil: CS								
4G Harvested wood products										
Harvested wood products	T2	DF	NA		NA		NA	NA	NA	NA

1.15.4.3 Recalculations

The main inventory improvements that were carried out and which led to recalculations were:

- Inclusion of the three separate land change maps:
  - 1990-2014
  - 2014-2018
  - 2018-2020
- Updated corrections and assumptions for the 2014-2018 change to correct for the change in land classification due to improved resolution of the maps
- Removal of “unlikely” conversions from all land change matrix
- Removal of potential seasonal variation for the conversion between Forest lands and Grasslands
- Inclusion of corrections for conversions from converted lands
- Inclusion of country specific BCEF factors for plantations
- Inclusion of disturbance matrix for plantations
- Updated the household fuelwood consumption factor
- Updated carbon stock data for the various land categories
- Inclusion of an assumption that the only cropland area that burned was sugarcane and that 90% of the sugarcane was burnt during pre-harvest and these emissions move to category 3.F
- Inclusion of the growth of biomass of the last 5 years of the maturity cycle in the cropland remaining cropland category
- Implementation of a corrected CH_4 emission factor for wetlands
- Incorporation of non-CO_2 emissions from biomass burning into LULUCF to align with ETF reporting requirements
- Change from SAR to AR5 GWPs

The recalculations showed the same trend between 1990 and 2014 as the previous data except that the sink was enhanced in this inventory. After 2014, with the introduction of the new land change maps, the LULUCF sector sink was reduced compared to the previous inventory. The sink then returned to previous levels in 2014 by 2019. In the previous inventory the 2020 estimated sink was -27 321 Gg CO_2, and in this inventory the LULUCF sink was estimated at -36 891 Gg CO_2 in 2020 (Figure 1.17).

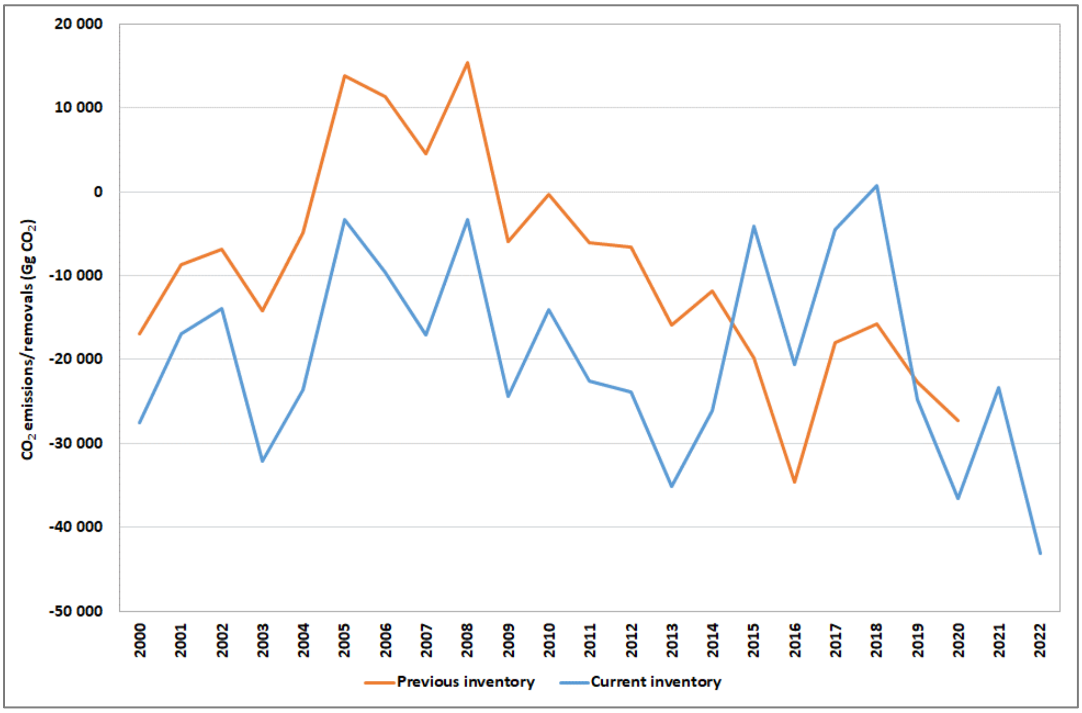

Figure 1.17: Change in LULUCF emission estimates due to recalculations since 2020 submission.

1.15.4.4 Planned improvements

The most critical factor in the LULUCF sector is the land use change data, particularly relating to thickets. The general land use change improvement plan will contribute significantly to improving this aspect of *Forest land*. Specific improvements for Forest land are to further assess the Stock-difference data for plantations and consider this for inclusion in the next inventory. Further data on litter for the various forest categories will be sought to start improving the DOM pool data as all pools are highlighted as being key for forest conversion.

The inventory will be improved over time by sourcing more crop specific biomass data. The management system classification for the various crops will be improved by following the decision tree given in IPCC 2006 Guidelines. Further the planned land change improvement plan will also lead to improvements for *Croplands*.

Besides the planned improvements around the land cover maps and actual change detection (i.e. removal of seasonal variation changes), further biomass data for low shrublands will be sought to reduce the uncertainty on this dataset. Grasslands remaining grasslands are shown to be a key category, and this category only includes the low shrubland data as pure grasslands are seen to be in equilibrium.

A more detailed assessment of *HWP* is required to include a wider range of products. This has not yet been done as funds would need to be made available for such a study. This is also supported by the verification process which highlighted the possible underestimate of the *HWP* sink.

1.15.4.5 Planned improvements

In terms of livestock there are six recommendations for improving estimates in the future:

- Improve livestock population data: There have been several studies on the emission factors and now the population data is the most uncertain component. Setting up a Livestock Estimates Committee could assist with this, although this has been mentioned before and not much progress has been made in terms of the committee. Further engagement is required between DFFE and the Department of Agriculture. It could also be an activity to discuss with the Agricultural Research Council which has a livestock division.
- National data set on manure management systems: This data seems to be highly variable depending on where the information comes from. In addition, data on the amount of manure being diverted to biogas needs to be included as this is a mitigation option and has been highlighted in previous inventory reviews. It is recommended to find a mechanism to track manure management practices or systems used in South Africa, as this could allow for incorporation of dynamics driven by changes in management regimes, and thus improve the

accuracy of manure related emissions.

- A detailed study on the herd composition of the various livestock and the number of days each livestock sub-category is alive in a year would contribute to a reduction in uncertainty.
- Collect and include in NIR background information of the livestock population original data sources (surveys, questionnaires etc.)
- Use appropriate MCFs depending on the average temperature for each year of the time series. Stratify the estimates depending on the average temperature in different regions in South Africa.
- Investigate if there are studies available about the burning of manure in South Africa.
- There is a need for alternate data source for lime data.

1.15.5 Waste

The Waste sector is a significant contributor to the rising levels of GHGs in the atmosphere. This section details the GHG emissions from managed landfills, open burning of waste, and wastewater treatment systems in South Africa, based on estimates using the IPCC 2006 Guidelines and the 2019 refinements for National Greenhouse Gas Inventories.

In South Africa's national Inventory, the Waste sector includes the main sources:

(i). 4A Solid waste disposal

(ii). 4C Open burning of waste

(iii). 4D Wastewater treatment and discharge

(iv). 4B Biological treatment of solid waste, including CH_4 and N_2O emissions

For a comprehensive account, emissions from waste incineration also need to be addressed. Additionally, emissions from using solid waste as fuel in Energy Industries and Manufacturing Industries are reported in the Energy Sector.

1.15.5.1 Trends

In South Africa, the Waste sector emitted a total of **20 698.43**Gg CO_2e in 2022 (Table 1.17), representing a significant portion of the national emissions. Most of the Waste sector emissions are from wastewater treatment and discharge accounting for 45% of the emissions, followed by Solid waste disposal accounting for 42%. Emissions from Biological treatment of solid waste and Open burning of waste only contribute 12% and 2% respectively.

Waste sector emissions have increased by 44.1% since 2000. For wastewater treatment and discharge while the overall emissions increased, emissions for industrial wastewater treatment and discharge have decreased by 8.6%. Emissions increased steadily between 2000 and 2022 (Figure 1.18).

Table 1.17: Summary of the estimated emissions from the Waste Sector in 2022

Categories	Emissions [Gg]							Total emissions
	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2	(Gg CO_2e)
5 - Waste	**28.91**	**682.05**	**5.93**	**NE**	**NE**	**NE**	**NE**	**20 698.43**
5A - Solid Waste Disposal		307.00		NE	NE	NE	NE	8 596.00
5A1 - Managed Waste Disposal Sites		307.00		NE	NE	NE	NE	8 596.00
5A2 - Unmanaged Waste Disposal Sites		NE		NE	NE	NE	NE	NE
5A3 - Uncategorised Waste Disposal Sites		NE		NE	NE	NE	NE	NE
5B - Biological Treatment of Solid Waste		61.99	3.00	NE	NE	NE	NE	2 530.38

Categories	Emissions [Gg]							Total emissions (Gg CO_2e)
	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2	
5C - Incineration and Open Burning of Waste	28.91	8.69	0.20	NE	NE	NE	NE	325.37
5C1 - Waste Incineration	NE	NE	NE	NE	NE	NE	NE	NE
5C2 - Open Burning of Waste	28.91	8.69	0.20	NE	NE	NE	NE	325.37
5D - Wastewater Treatment and Discharge	0.00	304.37	2.73	NE	NE	NE	NE	9 246.69
5D1 - Domestic Wastewater Treatment and Discharge		125.25	2.73	NE	NE	NE	NE	4 231.15
5D2 - Industrial Wastewater Treatment and Discharge		179.13		NE	NE	NE	NE	5 015.54
5E - Other (please specify)				NE	NE	NE	NE	NE

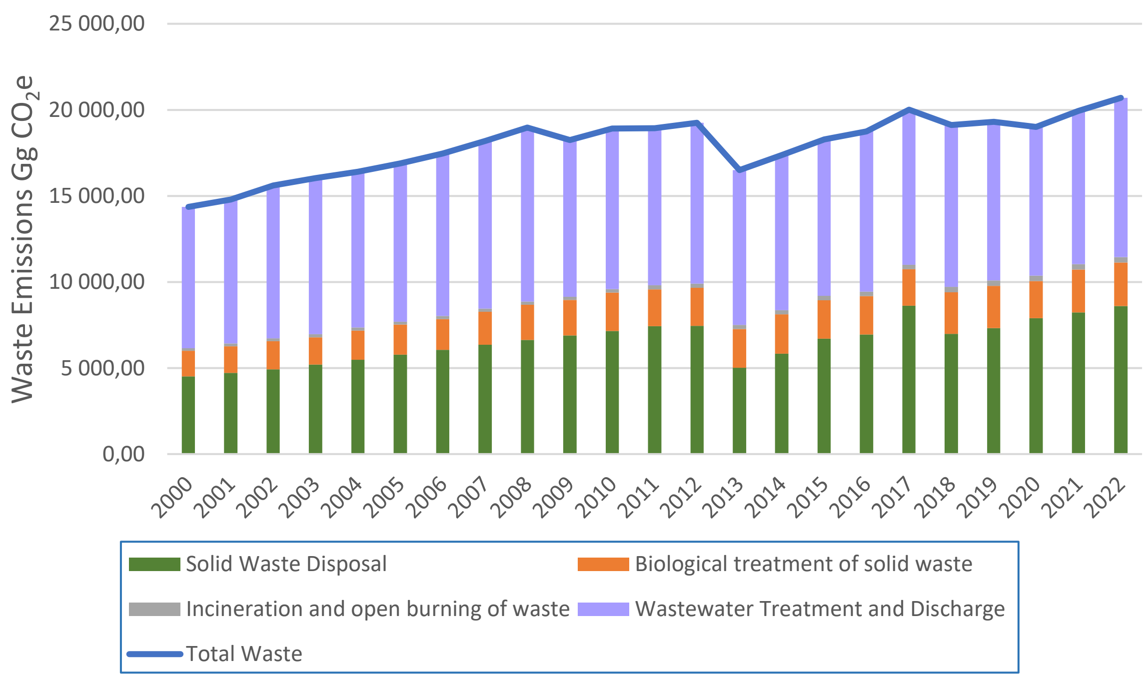

Figure 1.18: Trend in emissions from Waste sector, 2000 – 2022.

1.15.5.2 Recalculations

Recalculations were conducted for the Solid waste disposal category for all years from 2000 to the most recent inventory year (2022) due to the following updates:

- Updated the population data with the latest Statistics South Africa data
- Change from SAR to AR5 GWPs
- Updated COD values for various industries by reverting back to IPCC defaults due to variability in country specific COD
- Correction of units for biological treatment of solid waste category

1.15.5.3 Methods and data

The emissions for the Waste sector were calculated using available data or estimates based on surrogate data from scientific literature.

Table 1.18 outlines the methods and emission factors used for this sector. A major challenge in quantifying GHG emissions from various waste streams is the absence of regularly updated national inventory data. This includes data on the amounts of organic waste deposited in well-managed landfills, annual methane recovery from these landfills, the quantities of anaerobically decomposed organic matter from treated wastewater, and per capita annual protein consumption in South Africa.

Table 1.18: Summary of methods and emission factors for the Waste sector and an assessment of the completeness of the Waste sector emissions

GHG Source and sink category		CO_2		CH_4		N_2O		Details
		Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	
A	**Solid waste disposal**	NA	NA	T1	DF	NA	NA	Tier 1 FOD model was used.
B	**Biological treatment of solid waste**	NA	NA	T1		T1		2006 IPCC GL

C	**Incineration and open burning of waste**	T1	DF	T1	DF	T1	DF	2006 IPCC GL
D	**Wastewater treatment and discharge**	NA		T1	DF, CS	T1	DF	2006 IPCC GL

1.15.5.4 Planned improvements

Estimating GHG emissions in South Africa has been particularly challenging due to the lack of specific activity and emission factor data. Consequently, emissions from both solid waste and wastewater sources were primarily calculated using default values from the IPCC 2006 Guidelines, resulting in substantial margins of error. While no specific improvements are currently planned, South Africa has identified the following areas for potential enhancement in the improvement plan:

- Obtain data on the quantities of waste disposed of into managed and unmanaged landfills including its composition.
- Improve the classification of landfill sites.
- Improve the reporting of economic data (e.g., annual growth) to include different population groups. The assumption that GDP growth is evenly distributed (using a computed mean) across all the population groups is highly misleading and leads to exacerbated margins of error.
- Obtain information on population distribution trends between rural and urban settlements as a function of income; and
- Conduct a study to trace waste streams and obtain more information on the bucket system which is still widely used in South Africa.
- Collect data on CH_4 recovery at SWDS based on metering data.

1.16 References

IPCC, 2006, 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The National Greenhouse Gas Inventories Programme. Eggleston H S. Buenida L. Miwa K. Ngara T. and Tanabe K. eds; Institute for Global Environmental Strategies (IGES). Hayama. Kanagawa, Japan

IPCC, 2019, 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 3 Industrial Processes and Product Use, https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol3.html [Accessed: September 2022]

2 Information Necessary to Track Progress Made in Implementing and Achieving Nationally Determined Contributions Under Article 4 of the Paris Agreement

2.1 National Circumstances and Institutional Arrangements

2.1.1 Government structure

The Republic of South Africa is a constitutional democracy with a three-tiered system of government and an independent judiciary. The national, provincial and local levels of government all have legislative and executive authority in their respective spheres and the Constitution of the Republic of South Africa (RSA, 1996) defines them as distinct, interdependent and interrelated.

The Constitution of the Republic of South Africa (RSA) and all other relevant legislation and policies applicable to government to address environmental management, including climate change give effect to citizens' constitutional right to an environment that is not harmful to their health or well-being, as well as to protect the environment for the benefit of current and future generations.

The Climate Change Act 22 of 2024 addresses issues related to institutional and coordination arrangements across the three spheres of government, namely national, provincial, and local.

Situated at the southern tip of Africa, South Africa is bordered by the Atlantic Ocean to the west and the Indian Ocean to the south and east, with neighbouring countries including Namibia, Botswana, Zimbabwe, Mozambique, eSwatini, and Lesotho. The country features both subtropical climates in inland regions and temperate climates along the coast, with an average daily temperature of 20°C.

Between 2017 and 2020, South Africa's population increased by 5.48%. In 2017, the population stood at 56.52 million, growing to 58.78 million in 2019 and reaching 59.62 million in 2020. During the same period, the unemployment rate rose by 2.3%, reaching 29% in 2020. The country's GDP declined from USD 349.554 billion in 2017 to USD 301.9 billion in 2020, largely due to challenges exacerbated by the global COVID-19 pandemic.

Between 2017 and 2019, there was a 5.12% decrease in the primary energy supply, totalling 340,810.31 TJ of energy. Regarding land and agriculture, the total area dedicated to commercial agriculture remained stable at 46.4 million hectares from 2017 to 2020. In terms of waste management, the total waste generated in South Africa doubled from 54.2 million tonnes in 2017 to 108 million tonnes in 2020.

South Africa is characterized by its emerging economy and holds the distinction of being the world's largest exporter of gold, platinum, and natural resources. The country's GDP and economic growth are primarily driven by mining, finance, trade, and government services.

South Africa has the highest per capita carbon dioxide (CO_2) emissions in Africa and among developing nations. This distinction primarily stems from the country's heavy reliance on fossil fuel-based energy systems, notably coal and diesel thermal power generation, as well as substantial emissions from the transportation sector. The rising frequency of extreme weather events, including floods and droughts, attributed to global warming and climate change, underscores the urgent need to address climate impacts. These events are exacerbating poverty and food insecurity in both rural and urban poor communities across South Africa.

In response, the South African government is urged to prioritize investments in green technologies to facilitate the country's transition to a low-carbon economy. This strategic shift aims to mitigate vulnerability to climate risks, reduce the devastating impacts of climate change, alleviate poverty, and enhance livelihoods and well-being. As a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), South Africa remains committed to stabilizing greenhouse gas (GHG) concentrations in the atmosphere and limiting global average warming to below 2°C above pre-industrial levels.

This chapter provides an overview of South Africa's population, economy, energy dynamics, and climate variability impacts, offering context for the country's opportunities and challenges in addressing climate change. The institutional arrangements in place to track progress made in implementing and achieving the country's Nationally Determined Contributions (NDC) and the progress made in implementing and achieving the NDC targets.

2.1.2 Population profile

According to estimates from Statistics South Africa (StatsSA) for 2022, South Africa's population stood at 62 million. Despite being the smallest of South Africa's nine provinces, Gauteng is home to 15.1 million people, making up 24.3% of the total population, the largest share among the provinces. KwaZulu-Natal follows with an estimated 12.4 million people, comprising 20% of the population, while the Free State has the smallest population share at about 3 million people (4.8%) (StatsSA, 2022).

In 2020, StatsSA reported that 67.35% of South Africa's population resided in urban areas and cities. Significant migration occurred between 2016 and 2021, with Gauteng and the Western Cape receiving the largest numbers of migrants, approximately 1,553,162 and 468,568 respectively (StatsSA, 2021). The trend of rural to urban migration is expected to persist, exerting additional strain on urban governance and service delivery amid the challenges posed by climate change (DPSA, 2016).

StatsSA's mid-year population estimates for 2021 highlight the impact of the COVID-19 pandemic on South Africa. Mortality rates surged, with the crude death rate rising from 8.8 per 1,000 people in 2020 to 11.6 deaths per 1,000 people in 2021. Adult deaths increased by 34% in 2021, resulting in declines in life expectancy at birth: from 62.4 years to 59.3 years for males and from 68.4 years to 64.6 years for females between 2020 and 2021 (StatsSA, 2021).

2.1.3 Geographical profile

South Africa, situated at the southernmost point of the African continent, boasts a coastline spanning over 3,000 km. This coastal stretch runs from the Namibian desert border in the west to the Mozambique border in the east, flanked by the Atlantic Ocean on the west coast and the Indian Ocean on the east. South Africa borders Botswana, Namibia, and Zimbabwe, with Mozambique and Eswatini to the northeast. Additionally, the landlocked kingdom of Lesotho is entirely surrounded by South African territory.

South Africa spans an area of 1,219,602 square kilometres, stretching from 22°S to 35°S latitude and 17°E to 33°E longitude (GCIS, 2020). The country is characterized by three main geographical regions: a wide central plateau, surrounded by mountain ranges to the west, south, and east, and a narrow coastal plain. The Central Plateau dominates nearly two-thirds of South Africa's landmass (GCIS, 2020). Rising abruptly from the plateau are various mountain ranges that gradually slope down to sea level. This transition is marked by the Great Escarpment, which ranges in elevation from 2,000 to 3,300 meters (GCIS, 2020). Figure 2.1 illustrates the location map of the Republic of South Africa, depicting the Great Escarpment and the central plateau.

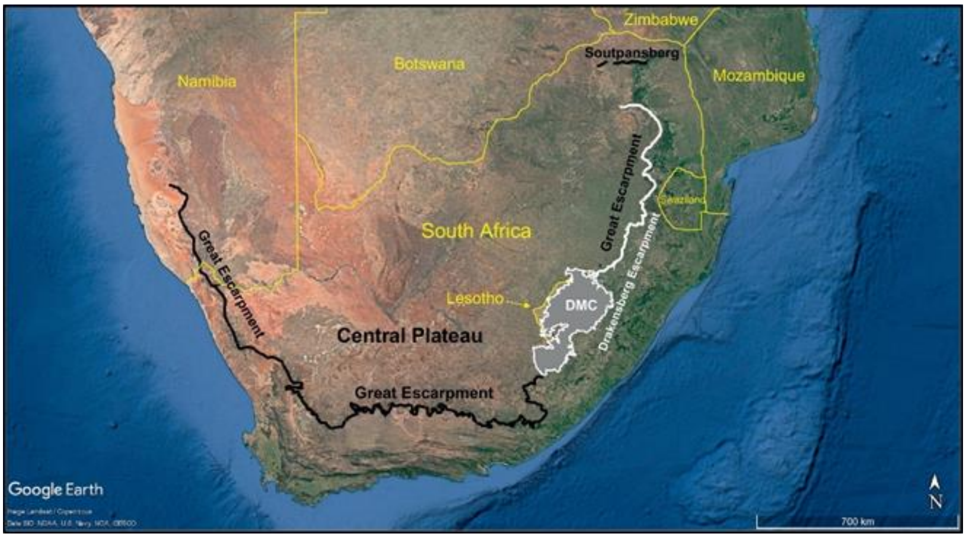

Figure 2.1: Google earth image of Southern African Central Plateau and Great escarpment (Source: CARBUTT (2019)

2.1.3.1 Description of Key Geographical Features

South Africa experiences a semi-arid climate, with an average annual precipitation of approximately 500 mm (GCIS, 2020). The Western Cape receives most of its rainfall during winter, while the rest of the country is characterized by summer rainfall. The country's subtropical position, influenced by its three-sided ocean exposure and the altitude of the central plateau, contributes to its warm temperate climate. Compared to other regions at similar latitudes, South Africa generally has cooler temperatures due to its higher elevation above sea level. On the central plateau, where Johannesburg lies at an altitude of 1,694 meters, average summer temperatures remain below 30°C. Winter nights can be frosty in some areas due to the elevation. Coastal regions of South Africa enjoy relatively mild winters. The east and west coasts experience distinct temperature variations due to the warm Agulhas Current and the cold Benguela Current, respectively (GCIS, 2020).

South Africa exhibits a diverse range of climatic conditions, transitioning from Mediterranean in the southwest to temperate across the central plateau and subtropical in the northeast (GCIS, 2020). A desert climate is present in a small area in the northwest of the country (GCIS, 2020). The country's varied geographical landscapes play a crucial role in shaping these distinct climates (GCIS, 2020), with elevation, terrain, and ocean currents exerting more influence on temperatures than latitude alone. South Africa typically enjoys warm, sunny days and cool nights (GCIS, 2020).

Currently, South Africa is experiencing increased occurrences of extreme weather events, attributed to observed changes in the climate system. The year 2020 was notably warm compared to previous years, partly due to above-average rainfall across much of the country. Data from 26 climate stations indicate that the annual mean temperature anomalies in 2020 were slightly higher on average than during the reference period (1981-2010), ranking it as the 13th warmest year since 1951. The country is undergoing a warming trend of 0.16°C per decade, a statistically significant change at the 5% level (SWS, 2021). The annual mean surface temperature deviation for South Africa is illustrated in Figure 2.2 below.

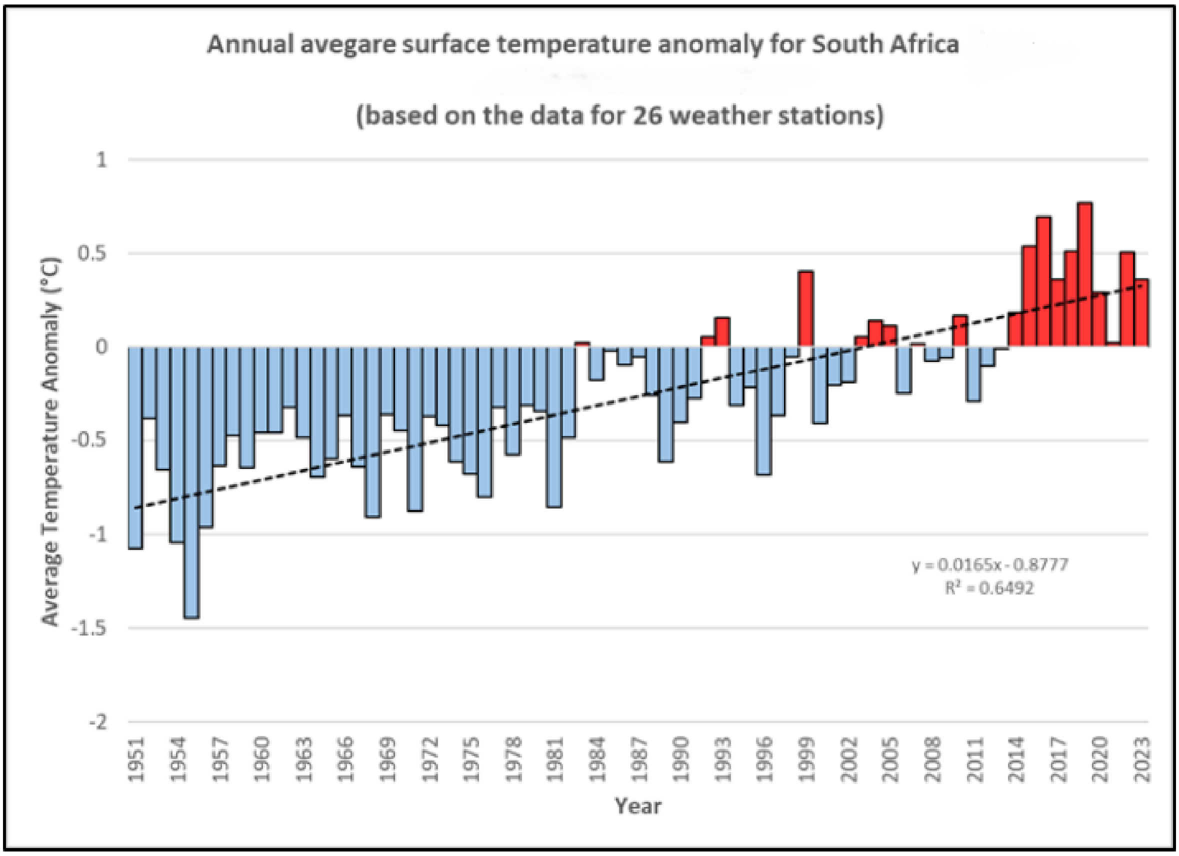

Figure 2.2: Annual average surface temperature deviation for South Africa. Source: SAWS (South African Weather Services) (2023)

South Africa has witnessed a notable increase in the frequency and severity of extreme weather events. Since 2013, the country has faced prolonged and intensified drought conditions, alongside devastating flash floods in various regions. One of the most severe droughts occurred in 2018, prompting cities like Cape Town to implement water restrictions in anticipation of a potential "day zero" crisis, where water sources would be insufficient to meet demand.

In the Eastern Cape and Northern Cape regions, recurring droughts from 2015 to 2018 led to crop failures and significant livestock losses, impacting farmers' livelihoods and the nation's food and water security. The Knysna fires of 2017, exacerbated by droughts and strong winds linked to climate change (Le Maitre et al., 2019), were among the worst fire disasters in South Africa's history. These fires displaced over 10,000 people and caused extensive damage to both natural habitats and properties.

The insurance and forestry sectors, along with government, incurred direct costs of at least ZAR 3 billion due to the fire disaster. Additionally, the Cape Storm of June 2017 brought unprecedented winds of 120 km/h and 12-meter-high waves, resulting in severe damage to over 100 schools, widespread flooding of homes, and at least 8 fatalities.

More recently, in April 2022, flash floods and landslides in KwaZulu-Natal Province caused by extreme rainfall resulted in 448 fatalities, displaced over 40,000 people, and destroyed at least 12,000 homes. These extreme weather events are increasingly attributed to global climate changes driven by global warming (Engelbrecht et al., 2022).

2.2 Legal Arrangements

2.2.1 Climate commitments and overarching climate policy

South Africa's NDC commitments for the period between 2020 and 2030 were approved by parliament in 2021. The NDC states the country's medium-term objectives, for the period of 2021 to 2030 to be in the range of 398 to 420 million tonnes of carbon dioxide equivalent emissions (Mt CO_2e). This target is divided into two implementation periods with the period of 2021-2025 South Africa's annual GHG emissions will range from 398 to 510 Mt CO_2e, while for the 2026-2030 period, the annual emissions will range from 350 to 420 Mt CO_2e (RSA, 2021). This approval solidified South Africa's commitment to achieving net zero emissions by 2050 in the long term.

2.2.1.1 National Development Plan, 2030

The overall objective of the NDP Vision 2030 is to eliminate poverty and reduce inequality by 2030 (NCP, 2011). Chapter 5 of the NDP aims to ensure that by 2030 South Africa is an environmentally sustainable society, with an expanded low-carbon economy and reduced emissions while at the same time reducing poverty, unemployment and social inequities. This chapter provides various mitigation objectives and outlines actions for achieving these goals by 2030, such as:

- Achieving the peak, plateau and decline GHG emission trajectory.

- Entrenching an economy-wide carbon price.
- Developing zero-emission building standards.
- Reducing the total volume of waste disposal to landfill each year.

A review of the NDP was completed in 2022 which led to the development of a framework to translating the NDP's top goals into short to medium-term (3-5 years) actions and in this way (NPC, 2022). The framework informs short to medium-term strategic plans such as medium-term strategic frameworks (MTSF) and Annual Performance Plans (APPs).

2.2.1.2 National Climate Change Response Policy

The National Climate Change Response Policy (NCCRP) sets out an overall climate change policy framework for South Africa articulating country's vision for an effective climate change response and the long-term, just transition to a climate-resilient and lower-carbon economy and society (DEA, 2011a). The objectives and goals of the NCCRP were informed by other national and international commitments, including the South African Constitution (Act No. 108 of 1996), the Bill of Rights, the National Environmental Management Act (Act No. 107 of 1998), the Millennium Declaration (UN Millennium Summit, 2000) and commitments made under the UNFCCC. The objectives of the policy are to effectively manage inevitable climate change impacts through interventions that build and sustain South Africa’s social, economic and environmental resilience and emergency response capacity. Furthermore the policy seeks to ensure the country makes a fair contribution to the global effort to stabilise GHG concentrations in the atmosphere at a level that avoids dangerous anthropogenic interference with the climate system within a timeframe that enables economic, social and environmental development to proceed in a sustainable manner (DEA, 2011a).

2.2.1.3 Climate Change Act 22 of 2024

In June 2018, South Africa released a draft National Climate Change Bill (DEA, 2018b) for public consultation. The Bill was tabled in Parliament in February 2022 (DFFE, 2022a) and underwent legislative processes to become the Climate Change Act in 2024. The Climate Change Act 22 of 2024 provides a regulatory framework for managing climate change impacts by enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change. In doing so, it also aims to make a fair contribution to the global effort to stabilise GHG concentrations in the atmosphere. In terms of the mitigation system, the Act makes provision for the development and review of the national GHG emission trajectory, the setting of sectoral emission targets (SET) to sectors and sub-sectors and allocating carbon budgets to companies. SETs are qualitative or quantitative goals informed by sectoral policies and measures that may lead to greenhouse gas emission reductions for the sector or sub-sector over a defined period. Carbon budgets will be developed to specifically cover industry, and the threshold will be published by DFFE.

The Minister of DFFE is required to publish a list of GHG emitting activities specified in the Climate Change Bill 2022 regulations. This list applies to both existing and new GHG emitting activities. The notice must establish specific emission thresholds in CO_2e for identifying individuals that are subject to a carbon budget under the Climate Change Bill 2022 regulations. Those individuals are required to submit GHG mitigation plans to the Minister.

Additionally, the notice excludes activities that emit GHGs below the established emission thresholds. Furthermore, the Minister also determines the effective date of this notice. The emission thresholds are expressed in CO_2e, applicable at the company level based on operational control, and are influenced by the feasibility of mitigation technology and the practicality of policy implementation.

2.2.1.4 Presidential Climate Commission (PCC)

The Presidential Climate Commission (PCC) is an independent, statutory, multistakeholder body established by President Cyril Ramaphosa. The purpose is to oversee and facilitate a just transition to a low-emissions and climate-resilient economy and support the policy aspects of the Just Transition associated with Climate Change Mitigation. These include conducting the National Employment Vulnerability Assessment Sectors Jobs Resilience Plans (SJRPs) and supporting the Presidency with the Just Energy Transition Implementation Plan. The PCC further engage a wide range of stakeholders, including all spheres of government, business, labour, academia, communities, and civil society, towards creating a social partnership around a just transition.

2.2.2 Overarching Mitigation Policies to Support Implementation

2.2.2.1 National GHG Emission Reporting Regulations and Pollution Prevention Plans

The National Greenhouse Gas Emission Reporting Regulations (NGERs) (DEA, 2017a), under Section 53(a), (o) and (p) read with section 12 of the National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004), in the Government Gazette of the 3rd April 2017, provides a foundation for the national reporting system for GHG emissions. NGERs introduced a single national reporting system for the transparent reporting of GHG emissions, which will be used (a) to update and maintain an inventory; (b) for the Republic of South Africa to meet its reporting obligations under the UNFCCC and instrument treaties to which it is bound; and (c) to inform the formulation and implementation of legislation and policy. The NGERs were amended in 2020 (DEFF, 2020). Companies will submit emissions data to the South African GHG Emissions Reporting System (SAGERS) (discussed above) which is a component of the National Atmospheric Emissions Inventory System (NAEIS). In accordance with regulation 7(1) of the NGERs the initial reporting cycle commenced on 31 March of 2018 requiring data providers to register and submit activity and GHG emissions data to the competent authority (DFFE).

2.2.2.2 Carbon Tax Act

The Carbon Tax Act No 15 of 2019 (RSA, 2019a) has been implemented since the 1 June 2019. The carbon tax regulations were amended since 2020 included in the Taxation Laws Amendment Act, 2021, Act No. 20 of 2021 (RSA, 2022) and the Taxation Laws Amendment Act, 2022, Act No. 20 of 2022. The timeline for carbon tax to run from the 1 January 2023 to the 31 December 2025 (RSA, 2023).

2.2.2.3 Carbon Offset Regulations

Carbon offsetting allows registered tax paying organisations to compensate for their GHG emissions by supporting projects that reduce emissions elsewhere in the country. It is a regulated activity under section 19(c) of the Carbon Tax Act, 2019 (Act No.15 of 2019). The regulations explain who can participate in these projects and what they need to do to be eligible and outlines how taxpayers can claim the carbon offset allowance. Additionally, the regulations cover the management and organisation of the carbon offset system to ensure it runs smoothly and fairly. The carbon offset tax-free allowance assists tax paying organisations to cost-effectively reduce their emissions and carbon tax liability by up to 10 % of their total GHG emissions by investing in GHG emissions mitigation projects.

The National Treasury gazetted amendments to the Carbon Offsets Regulations in terms of Section 19 (c) of the Carbon Tax Act on 8 July 2021 (National Treasury, 2021a).

The Department of Mineral Resources and Energy (DMRE) is currently working on releasing a preliminary plan for local standards that can be used to determine whether a project qualifies as a carbon offset project. This plan was developed with the support of the World Bank's Partnership for Market Readiness project and will be made available for public input and feedback (DMRE, 2022). The department will also explore the possibility of including offset projects from other African countries as part of the second phase of the carbon tax review and design process.

The National Treasury has proposed that the utilisation period in the Carbon Offsets Regulations should be changed to align with the first phase of the Carbon tax from 1 January 2023 to 31 December 2025, which will take effect from 1 January 2023 (National Treasury, 2023a). Furthermore, the National Treasury plans to evaluate stakeholder feedback in 2023 regarding the feasibility of establishing a domestic marketplace for trading tax credits generated by the carbon tax. The consultation will specifically address various essential components needed for smooth trading, such as determining the financial asset status of carbon credits, establishing trading and post-trade market structures, issuing licenses for private carbon credit funds and implementing carbon credit certification.

2.2.2.4 Carbon Sequestration in the Carbon Tax Act

In terms of the Carbon Tax Act, Section 4(1) and 4(2)(a) defines the carbon tax base that is, fuel combustion, fugitive and industrial process emissions that are determined using the Tier 3 company-based emissions methodologies or the Tier 1 and 2 emission factors as per Schedule 1 of the Carbon Tax Act, respectively.

The Carbon Tax Act allows taxpayers to deduct sequestered emissions as verified and certified by DFFE from their energy combustion related greenhouse gas emissions for a tax period as determined in Section 4 of the Act. DFFE gazetted the regulations which set out methodological guidelines for quantifying carbon sequestration in the forestry sector on 28 January 2022.

Sequestrated emissions cover carbon capture and storage (CCS) in geological reservoirs and biological sequestration including forests.

2.2.2.5 Trade Exposure Allowance Regulations

The maximum trade exposure allowance available to entities that are trade exposed and sensitive to international competitiveness has been increased from 30% to 50% from 1 January 2023.

2.2.2.6 GHG Emission Intensity Benchmark Regulations

The Regulations for the Greenhouse Gas Emissions Intensity Benchmarks were gazetted in 2020 under section19 (a) of the Carbon Tax Act, 2019 (Act No.15 of 2019) for purposes of section 11 for the Performance Allowance (National Treasury, 2020). The performance allowance aims to incentivise companies to decrease the carbon intensity of their production processes compared to their industry counterparts. It also aims to enhance the competitiveness of local products. The gazetted Regulations for the GHG Emissions intensity benchmarks sets out the emissions intensity benchmarks for sectors and subsectors that submitted benchmark proposals during the period 2016 to 2020. The date of commencement of the regulation is 1 June 2019.

2.2.2.7 Renewable Energy Premium

Section 6(2)(c) of the Carbon Tax Act outlines a provision allowing electricity generators who are subject to carbon tax to reduce their carbon tax liability by accounting for the expenses associated with acquiring additional renewable energy. Initially, this deduction was limited to Eskom and its renewable energy purchases within the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) framework. However, it has now been broadened to encompass other electricity generators, making renewable energy purchases through either the REIPPPP or private transactions.

To address this expansion, a proposal is being made to restrict eligibility for the tax deduction. Eligibility would be limited to entities that meet the following criteria: they are liable for carbon tax, they engage in electricity generation activities, and they directly procure primary renewable energy, either through the REIPPPP or from private independent power producers (IPPs). This proposed tax deduction for renewable energy purchases would only apply to those made within the REIPPPP or through private transactions that involve a power purchase agreement (PPA). (National Treasury, 2022a).

For purposes of Section 6(2)(c) of the Carbon Tax Act, a power purchase agreement (PPA) is a long-term electricity supply agreement between a renewable power producer and electricity consumer (buyer or off taker). PPAs can exist for onsite renewable electricity purchases where there is direct supply of electricity to the buyer and offsite electricity purchases where the producer supplies electricity to the buyer through the national grid (National Treasury, 2022a).

2.3 Measurement Reporting and Verification (MRV)

2.3.1 Institutional Arrangement M&E in Tracking Progress Made in Implementing and Achieving Nationally Determined Contributions under Article 4 of the Paris Agreement

The Department of Forestry, Fisheries, and the Environment (DFFE) (Figure 2.3) is responsible for the coordination and management of all climate change-related information in South Africa, including mitigation, adaptation monitoring and evaluation, and greenhouse gas (GHG) inventories (discussed in Chapter 1 of this BTR). As the UNFCCC focal point, the DFFE plays a crucial role in ensuring that the country's climate actions are effectively tracked and reported. The Department of Forestry, Fisheries and the Environment (DFFE) is responsible for co-ordinating and policy-making with respect to environmental conservation. The Air Quality Act (Act 39 of 2004) (RSA, 2004) provides the mandate to the DFFE to formulate, co-ordinate and monitor national environmental information, policies, programmes, and legislation. The DFFE (Figure 2.3) is responsible for co-ordination and management of all climate change-related information, including the compilation and update of National GHG Inventories (discussed in Chapter 1 of this BTR) The compilation of the GHG emissions inventory and the NIRs are managed through the National Greenhouse Gas Information System (NGHGIS) and are the responsibility of the Climate Change Mitigation and Specialist Monitoring Services Chief Directorate in DFFE. The UNFCCC focal point sits within the International Climate Change Relations and Reporting Chief Directorate in DFFE and is responsible for the compilation and submission of the NIR, BTR and NC reports to the UNFCCC.

The Chief Directorate: Climate Change Mitigation & Specialist Monitoring Services (CCM&SMS) oversees the monitoring and evaluation of climate change responses. Within this chief directorate, the Directorate Climate Change Monitoring and Evaluation: Mitigation Response Analysis plays a critical role in tracking policies related to NDCs. This directorate is also responsible for developing and managing analytical tools, such as models, to analyse greenhouse gas data, assess mitigation potential of reported Policies, measures and actions in the NCCRD, explore GHG mitigation pathways, and evaluate socio-economic impacts is responsible for analysing data on NDC Tracking Policies and measures and DFFE updates mitigation, adaptation, and finance data to the National Climate Change Response Database.

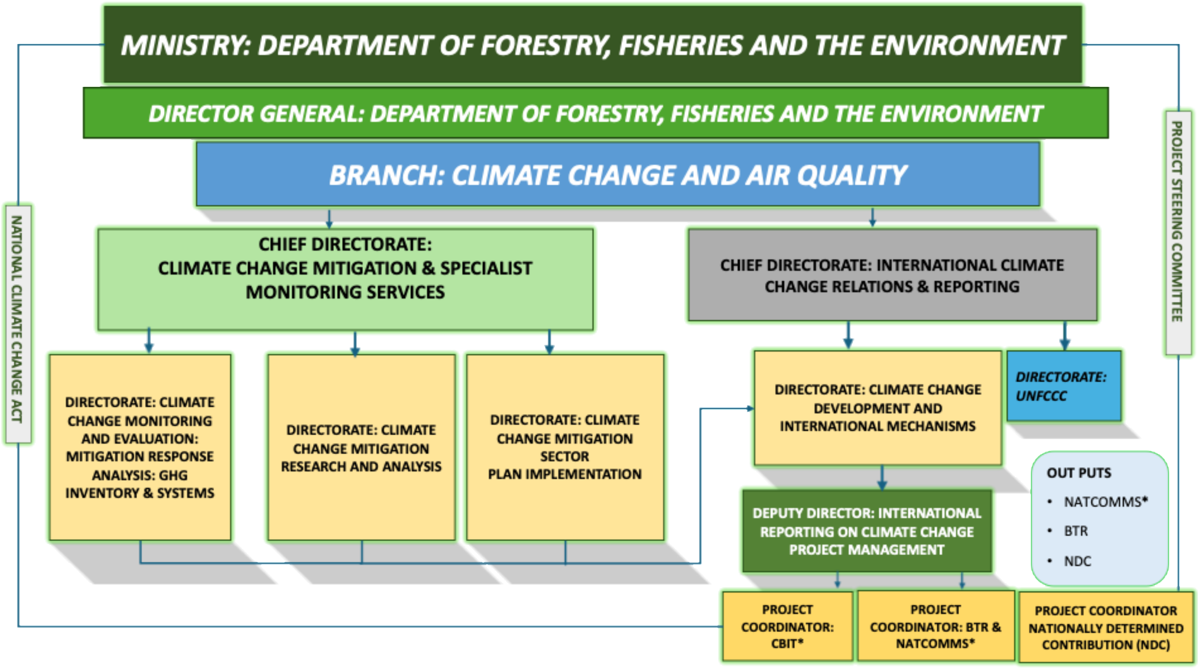

Figure 2.3: Overview of the DFFE Climate Change and Air Quality Branch

Data for tracking progress on implementing and achieving nationally determined contributions (NDCs) under Article 4 of the Paris Agreement is collected from various data providers including municipalities, provinces, programme and project developers , imported into the Provincial Climate Change Response Databases (currently operational only in Mpumalanga), and then compiled into the National Climate Change Response Database (NCCRD). This only applies for the Mpumalanga province, which has a provincial climate change database. The other data providers input data directly into the National Climate Change Response database, which is part of the National Climate Change Information System (NCCIS). The platform offers a series of decision support tools to inform policy and decision-making including a database of adaptation and mitigation actions undertaken by stakeholders across the country. The NCCIS includes sub-national systems and sector specific systems building on the work that has already been done on the NCCIS.

The NCCIS is supported by national, provincial, and local scale systems of data-collection to provide detailed, complete, accurate and up to date data that ranges across adaptation and mitigation related topics (Figure 2.4). The information is contained within the themes of:

- Climate Information.
- Climate Services.
- Tracking and Evaluation (T&E) Portal.
- Carbon Sinks Atlas.

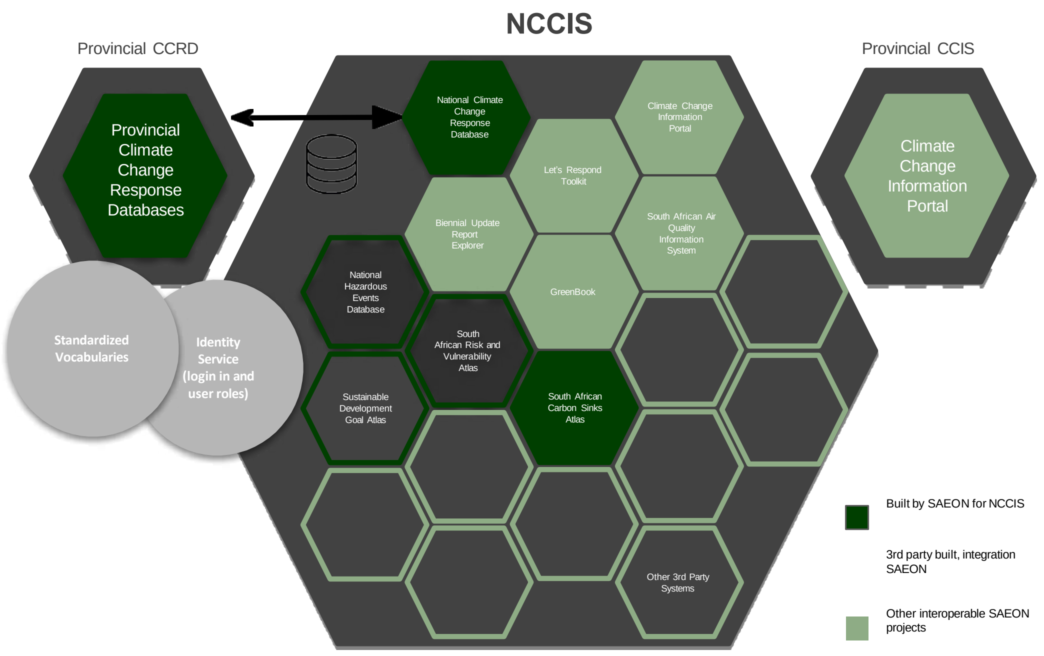

Figure 2.4: A diagram of the South African National Climate Change Information System (NCCIS) and its various expandable components

The NCCIS is managed by DFFE Climate Change Mitigation and Specialist Monitoring Services who has the responsibility of ensuring that various tools on the system are updated and that the various data providers update their information on the system. This includes drawing the information from the NCCIS to the inventory and initiating projects to update the tools on the NCCIS. This should be done every few years and will require financial support to complete.

Furthermore, the: GHG Inventory & Systems within the CCM & SMS chief directorate is tasked with compiling the National Inventory Reports (NIRs). The South African Greenhouse Gas Emissions Reporting System (SAGERS) facilitates the institutionalization of the National GHG Inventory. Data providers in the industry report on their GHG emissions estimates through the SAGERS as regulated by the Mandatory GHG Reporting regulations. The NGERs allows for the collection of data from the energy sector and industries (including plantation industries and certain agricultural industries). The NGERs were promulgated in fulfilment of the implementation of the regulatory framework to support the collection of the requisite activity and GHG emissions data necessary for the compilation of the National GHG emissions Inventory to improve the quality, sustainability, accuracy, completeness and consistency of the National GHG Inventories. In accordance with regulation 7(1) of the NGERS the initial reporting cycle commenced on 31 March of 2018 requiring data providers to register and submit activity and GHG emissions data to the competent authority, namely DFFE.

As required in the 2011 White Paper (DEA, 2011), the DFFE has subsequently developed the South African Greenhouse Gas Emissions Reporting System (SAGERS) which is the GHG module of the National Atmospheric Emissions Inventory System (NAEIS). The SAGERS module helps to facilitate the process of enabling Industry to meet its GHG reporting requirements in a web-based secure environment and facilitates the data collection process for energy related activities and IPPU. The DFFE Climate Change Mitigation and Specialist Monitoring Services Unit is responsible for managing the SAGERS system.

80% of the data needed for compiling the NIR of South Africa is collected through the reporting programme via SAGERS. The DFFE has developed technical guidelines on how to do calculations of emissions estimates and report them through the SAGERS. Furthermore, other data in the energy, IPPU, Waste and AFOLUI sectors is collected from different data providers as explained in the institutional arrangements for the GHG Inventory compilation. All this is used to compile the GHG Inventory every two years, and this process is coordinated through the central web-based National GHG Information Management System (NGHGIS). Once the NIR has been developed, it is shared with the International Climate Change Relations and Reporting Chief

Directorate, who also develop the GHG Emissions summary chapters in the BTR and NC and submit NCs and BTRs with stand-alone NIRs.

The NCCRD, a sub-module of the NCCIS, is specifically designed to track South Africa's progress towards NDC goals and commitments. Data from the NCCRD is then analysed and forwarded to the Chief Directorate: International Climate Change Relations and Reporting, which manages the compilation and submission of Biennial Transparency Reports and National Communications to the UNFCCC, ensuring accurate reporting of South Africa's climate actions and progress towards its NDCs.

The South African Weather Service is responsible for updating the climate data on the Climate Information Portal (CIP) and National Hazardous Events Database (NHED). The National Climate Change Response Database is currently updated by DFFE Climate Change Mitigation and Specialist Monitoring Services Unit. In future a system can be setup to automatically filter data from the Provincial Climate Change Response Databases (PCCRD) to the national system since similar vocabularies have been used to allow for integration. It is the responsibility of the provinces to update the PCCRDs. In the future it could be setup such that data is collected at the local municipality level and filtered through to the PCCRD and then to the NCCRD.

The DFFE Climate Change Mitigation and Specialist Monitoring Services unit is responsible for updating mitigation, adaptation and finance data to T&E system. The T&E Portal is a sub-module of the NCCIS specifically designed as a platform for tracking South Africa's progress towards NDC goals and commitments. The T&E Portal tracks South Africa's climate action and transparency under the Climate Change Paris Agreement in a transparent, simple, interactive, dynamic and informative manner to inform both the domestic and international audience.

Financial data is requested from donor organisations by DFFE Climate Change Mitigation and Specialist Monitoring Services who are also responsible for uploading the data to the T&E system. The DFFE together with National Treasury and other stakeholders collaborated on the development of a National Climate Finance Support Strategy that will enhance tracking climate finance.

The Climate Change Monitoring and Evaluations System support regular production of communication material that describes South Africa's climate change actions for local and international audiences. Once the information is analysed it is shared with the Climate Change Development and International Mechanisms Directorate to be included in the Biennial Transparency Report. Not all components of the NCCIS are fully functional.

The overall institutional arrangements and data flows for the MRV of GHG emissions, mitigation, adaptation, and support are shown in Figure 2.5. The components of South Africa's Tracking and Evaluation System is shown in Figure 2.6.

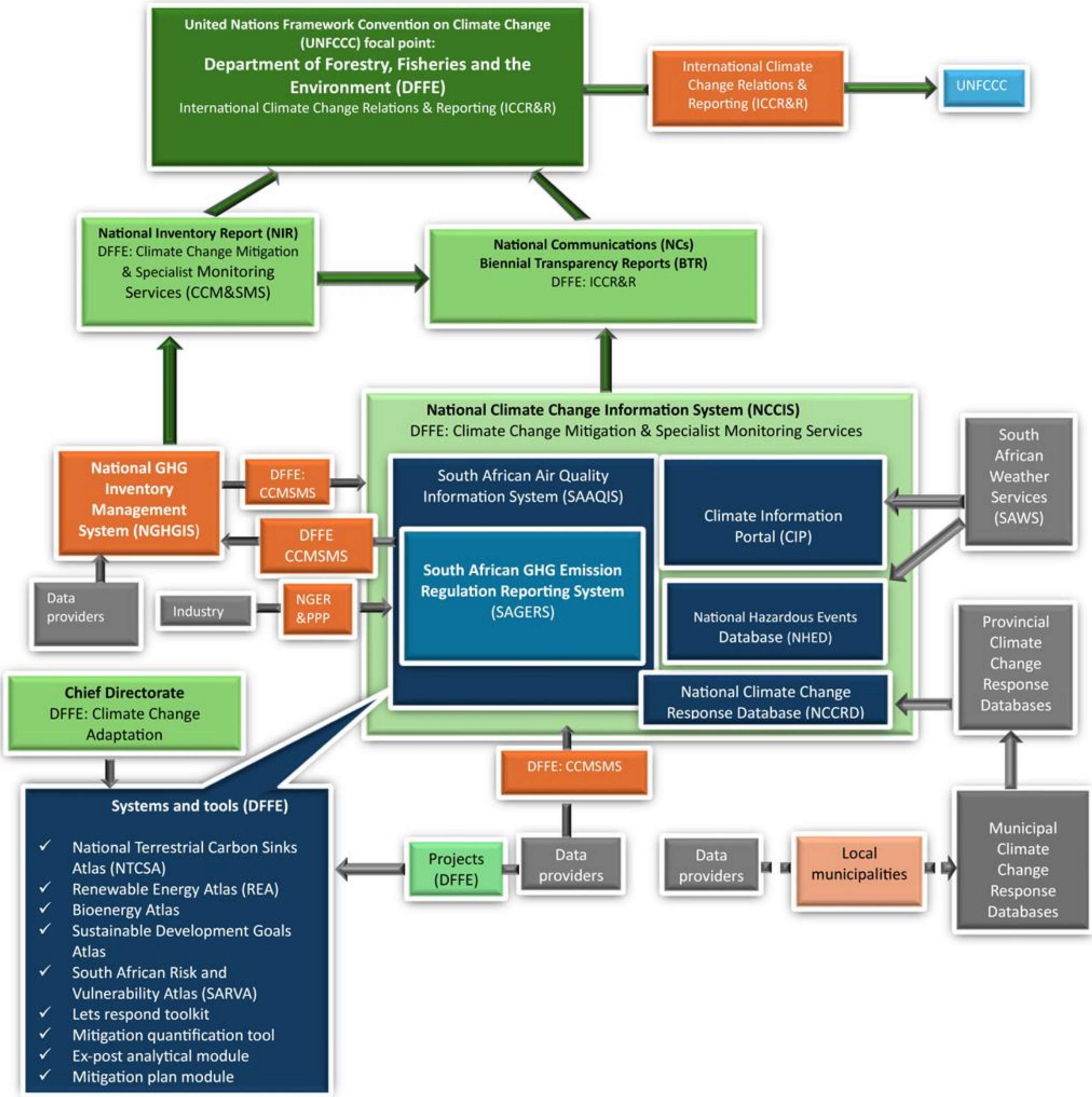

Figure 2.5: Diagram of the institutional arrangements and data flows for MRV in South Africa

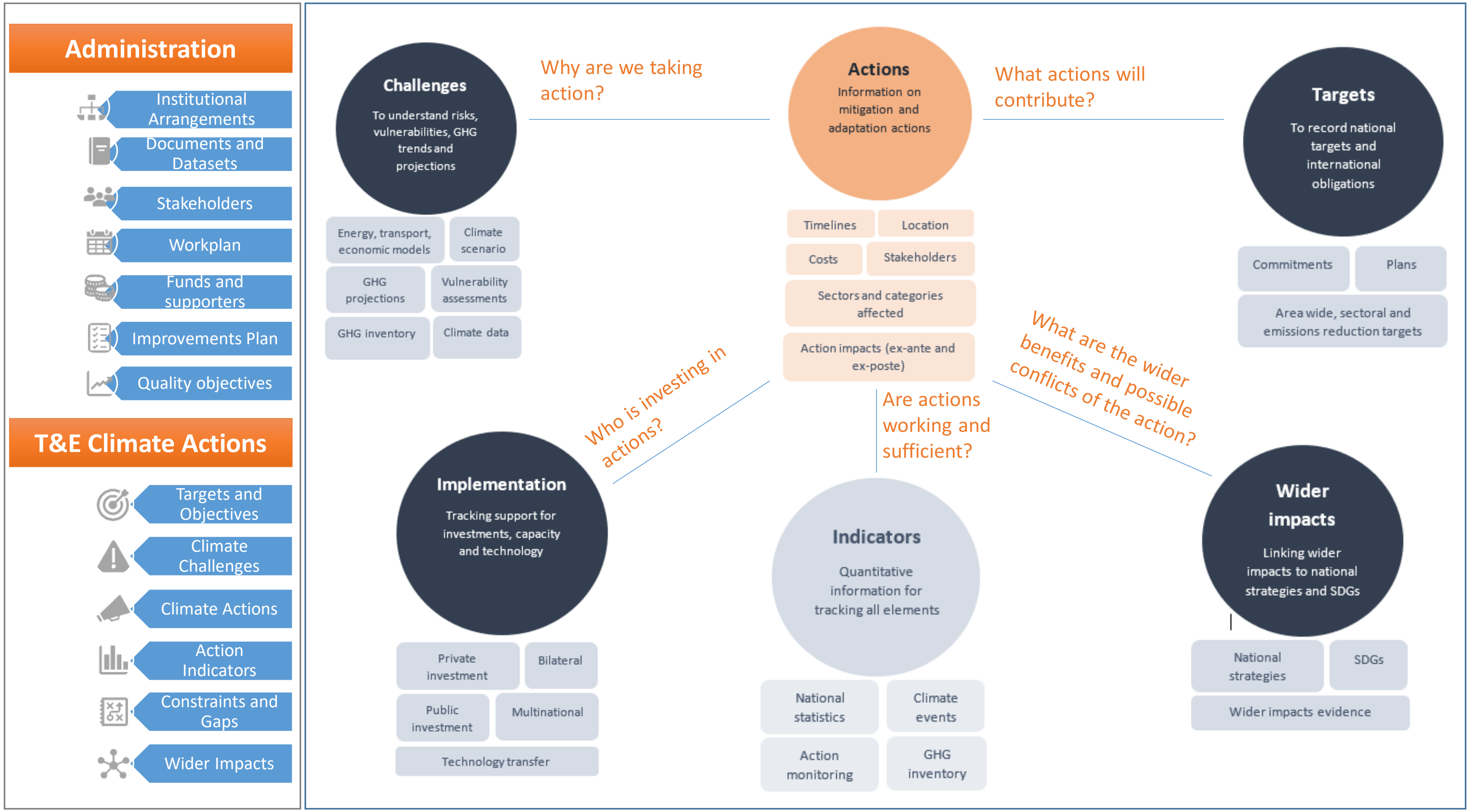

Figure 2.6: Components of South Africa's Tracking and Evaluation System.

Sub-national frameworks at a provincial level have institutionalised, with the Initiative for Climate Action Transparency (ICAT) guide on non-state and sub-national action developed by ICAT also being used to support sub-national entities. Through the support of external donor funding the Mpumalanga Climate Change Response Database (https://mccrd.environment.gov.za/s) has been developed. Similar processes are also underway in three other provinces namely KwaZulu-Natal, Western Cape and Northern Cape.

2.3.2 Climate mitigation system

The implementation of the mitigation elements of the National Climate Change Response Policy and the Climate Change Act is achieved by allocating Sectoral Emissions Targets (SETs) to policy sectors, Carbon Budgets, and associated mitigation plans to industry and supporting the verification process for the Carbon Tax regime administered by the National Treasury and the South African Revenue Service (SARS). A framework has been developed outlining the approach that the DFFE would follow when coordinating the process towards the allocation and implementation of SETs with the line sector departments, provinces and local governments. With the implementation of the Climate Change Act, the elements of the system will be legally enforceable. Figure 2.7

Figure 2.7: Climate mitigation system being developed for South Africa

Stakeholder engagement is an important process that supports the climate mitigation system. Currently climate related policies, regulations and communications (such as the NIR and BTR) undergo a process of public consultation and commenting. Specifically draft reports are published as a Notice in the Government Gazette or newspaper and the public are invited to submit written comments within given a specified time.

2.4 Description of a Party's nationally determined contribution under Article 4 of the Paris Agreement, including updates

South Africa has set new, economy-wide goals for reducing GHG emissions, with specific targets for the years 2025 and 2030. By 2025, the country aims to maintain its annual emissions between the range of 398 and 510 million tonnes of CO_2-eq (Mt CO_2-eq). For 2030, the target range is reduced to between 350 and 420 Mt CO_2-eq. The NDC thus have two single year targets.

The NDC does not use reference points, levels, baselines, base years, or starting points. Instead, the mitigation targets are defined as fixed levels of GHG emissions for the years 2025 and 2030.

The South African NDC is structured into two five-year periods: the first from January 1, 2021, to December 31, 2025, and the second from January 1, 2026, to December 31, 2030. It encompasses sectors, gases, categories, and pools consistent with the 2017 National Inventory Report (NIR), excluding emissions from natural disturbances in the land sector. The covered sectors include Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry, and Other Land Use (AFOLU), and Waste.

While the NDC aims for economy-wide coverage, a few subcategories are not estimated due to either the absence of certain activities in South Africa or lack of data. These omissions are documented in the 2017 NIR. The gases covered by the NDC include CO_2, CH_4, N_2O, HFCs, and PFCs. However, SF_6 and NF_3 are not included in the two implementation periods due to insufficient data. If data becomes available, these gases might be considered for inclusion in the 2026-2030 period or the next NDC.

The NDC accounts for the land sector but excludes emissions from natural disturbances. Both the 2017 NIR and the NDC adopt a land-based approach, including all carbon pools except for dead organic matter. Specifically, litter is included, but dead wood is not, as stated in the 2017 NIR.

South Africa hosts several Clean Development Mechanism (CDM) projects under the Kyoto Protocol. The recognition of these projects under Article 6 of the Paris Agreement is still under negotiation. It is expected that South Africa might host Article 6.4 projects and may enter into cooperative approaches with other countries under Article 6.2.

The coverage and scope of the mitigation targets in the NDC align with the 2017 NIR. The 2017 NIR uses Global Warming Potential (GWP) values from the IPCC's Second Assessment Report (AR-2), while the updated NIR uses GWP values from the IPCC's Fifth Assessment Report (AR-5). Replacing AR-2 GWP values with AR-5 values is expected to increase South Africa's total emissions estimate for the target years by 10-20 Mt CO_2-eq.

2.5 Information necessary to track progress made in implementing and achieving South Africa's nationally determined contribution under Article 4 of the Paris Agreement

South Africa's indicators to track progress made in implementing and achieving the NDC include the National GHG emissions (excl. LULUCF) and National GHG emissions (incl. LULUCF). Definitions of the indicators are provided in

Table 2.1. A description of the indicators for the reporting years of 2021 and 2022 are provided in Table 2.2.

Table 2.1:: Definitions needed to understand each indicator

Definitions:	
National GHG emissions (excl. LULUCF)	National GHG emissions (excluding LULUCF) refer to the total greenhouse gas emissions produced by South Africa, excluding emissions and removals from land use, land-use change, and forestry (LULUCF). This metric encompasses emissions from sectors such as energy, industrial processes, agriculture (excluding land-related emissions), and waste
National GHG emissions (incl. LULUCF)	National GHG emissions (including LULUCF) refer to the total greenhouse gas emissions produced by South Africa, encompassing all sectors, including land use, land-use change, and forestry (LULUCF). This includes emissions from energy production, industrial processes, agriculture, waste management, as well as emissions and removals resulting from activities related to deforestation, reforestation, afforestation, and other land-use changes.

Table 2.2: Indicators selected to track progress of the NDC

Indicators selected to track progress	Description
National GHG emissions (excl. LULUCF) in 2021	South Africa's National GHG emissions (excl. LULUCF) in 2021 are 488.32 Mt CO_2-eq.
Updates in accordance with any recalculation of the GHG inventory, as appropriate	The 2022 NIR used the AR5 GWPs. The 2020 NIR used the AR2 GWPs. The data shows that the current inventory estimates (excl. LULUCF) are between 0.43% and 5.3% lower than the 2020 inventory estimates.
Relation to NDC	South Africa's National GHG emissions (excl. LULUCF) in 2021 are within range of the mitigation targets for the period 2021 to 2025.
National GHG emissions (excl. LULUCF) in 2022	South Africa's National GHG emissions (excl. LULUCF) in 2022 are 478.89 Mt CO_2-eq.
Updates in accordance with any recalculation of the GHG inventory, as appropriate	The 2022 NIR used the AR5 GWPs. The 2020 NIR used the AR2 GWPs. The data shows that the current inventory estimates (excl. LULUCF) are between 0.43% and 5.3% lower than the 2020 inventory estimates.
Relation to NDC	South Africa's National GHG emissions (excl. LULUCF) in 2022 are within range of the mitigation targets for the period 2021 to 2025.
National GHG emissions (incl. LULUCF) in 2021	South Africa's National GHG emissions (incl. LULUCF) in 2021 are 464.96 Mt CO_2-eq.

Indicators selected to track progress	Description
Updates in accordance with any recalculation of the GHG inventory, as appropriate	The 2022 NIR used the AR5 GWPs. The 2020 NIR used the AR2 GWPs. The data shows that the current inventory estimates (incl. LULUCF) are between 0.23% and 4.94% lower than the 2020 estimates except for 2017 when emission were slightly higher.
Relation to NDC	South Africa's National GHG emissions (incl. LULUCF) in 2021 are within range of the mitigation targets for the period 2021 to 2025.
National GHG emissions (incl. LULUCF) in 2022	South Africa's National GHG emissions (incl. LULUCF) in 2022 are 435 828 kt CO_2-eq.
Updates in accordance with any recalculation of the GHG inventory, as appropriate	The 2022 NIR used the AR5 GWPs. The 2020 NIR used the AR2 GWPs. The data shows that the current inventory estimates (incl. LULUCF) are between 0.23% and 4.94% lower than the 2020 estimates except for 2017 when emission were slightly higher
Relation to NDC	South Africa's National GHG emissions (incl. LULUCF) in 2022 are within range of the mitigation targets for the period 2021 to 2025.

South Africa accounts for anthropogenic emissions and removals in accordance with methodologies and common metrics assessed by the IPCC and in accordance with decision 18/CMA.1. South Africa has adopted a GHG inventory-based method to track its mitigation targets for 2025 and 2030. The country uses guidelines and GWP values outlined in the Annex to decision 18/CMA.1 (or any subsequent CMA decisions) to estimate emissions for the national inventory report. Progress and achievement will be measured by comparing the target ranges for 2025 and 2030 with the annual emissions recorded in South Africa's GHG inventory across all sectors, excluding emissions from natural disturbances in the land sector. These emissions have been separated in the NIR for each relevant IPCC category and reported individually, forming the basis for accounting for the implementation and achievement of the NDC targets. By reporting about the NDC and the progress towards achievement of the target in this way using indicators, this shows that the indicator methodology in each reporting year is consistent with the methodology or methodologies used when communicating the NDC.

In the NIR, the entire land area is classified as “managed” for estimating emissions and removals in the land sector. CO2 emissions from biomass burning are currently recorded under losses due to disturbance in the land section (3B) rather than the biomass burning section (3C1). Emissions from wildfires are estimated and included in each relevant land category. For accounting South Africa’s NDC target, emissions from natural disturbances are excluded from the total. To account for emissions and removals from harvested wood products, South Africa employs a production approach, following the updated guidance in the 2013 IPCC Kyoto Protocol Supplement (IPCC, 2014). South Africa does not use a method to address the effects of age-class structure in forests

GHG emissions (excl. LULUCF) in 2021 are within range of the mitigation targets for the period 2021 to 2025. GHG emissions (excl. LULUCF) in 2022 are within range of the mitigation targets for the period 2021 to 2025. GHG emissions (incl. LULUCF) in 2021 are within range of the mitigation targets for the period 2021 to 2025. National GHG emissions (incl. LULUCF) in 2022 are within range of the mitigation targets for the period 2021 to 2025.

2.6 Mitigation policies and measures, actions and plans, related to implementing and achieving a nationally determined contribution under Article 4 of the Paris Agreement

2.6.1 Sectoral Mitigation Policies and Measures

2.6.1.1 Energy

1.6.1.1a) 12L Tax Incentive Program

The South African 12L tax incentive program is designed to encourage businesses to implement energy efficiency measures by providing tax deductions for verified energy savings. A summary of the program is provided in Table 2.3. Its main objectives are to promote energy conservation, reduce operational costs for businesses, and support the national agenda for sustainable development. By incentivizing the reduction of energy consumption, the program helps to lower overall demand for electricity, leading to a decrease in the use of fossil fuels for power generation. Consequently, this reduction in energy usage contributes to a significant decrease in greenhouse gas (GHG) emissions, aiding South Africa in its efforts to combat climate change and meet its environmental commitments. From 2010 to 2022; the program has contributed to reducing South Africa's GHG emissions cumulatively by 26.4 Mt CO_2-eq (shown in Table 2.4).

To claim benefits under Section 12L, a South African taxpayer must implement energy efficiency measures within their business operations and engage a SANAS-accredited Measurement and Verification (M&V) professional to establish baseline and post-implementation energy savings. The M&V professional will compile a report detailing the verified energy savings, which must then be submitted to SANEDI for approval. Upon approval, SANEDI will issue a certificate confirming the verified energy savings. This certificate must be submitted with the taxpayer's annual tax return to SARS to process the tax incentive claim. Section 12L became effective on 1 November 2013 and applies to years of assessment ending before 1 January 2026.

Table 2.3: Summary of Section 12L Tax Incentive Program

No.	Name	Description	Objectives	Type of instrument
1	12L Tax Incentive Program	The 12L tax incentive program allows eligible businesses to receive a tax deduction for their confirmed energy savings resulting from energy efficiency upgrades. Managed by the South African National Energy Development Institute (SANEDI), this initiative encourages investment in energy-efficient projects across multiple industries.	To incentivise companies to implement energy-saving measures and technologies, thereby contributing to a more sustainable and environmentally friendly economy.	Economic
Status	Sector affected	Gases affected	Start year of implementation	Implementing entity
Implemented	Energy	CO_2	2013	South African National Energy Development Institute (SANEDI)

Table 2.4: GHG emission reductions of the 12L Tax Incentive Program

Achieved		Expected
Year	Emission Reduction (Mt CO_2-eq)	
2010	0	FX
2011	0	
2012	0	
2013	0	
2014	5.71	
2015	0.97	
2016	4.11	
2017	4.54	
2018	2.16	
2019	6.19	

	Achieved	Expected
Year	Emission Reduction (Mt CO_2-eq)	
2020	1.34	
2021	0.48	
2022	0.9	
Total	26.4	

2.6.1.1b) Eskom Integrated Demand Management (IDM) Programme

The Eskom Integrated Demand Management (IDM) Programme is an initiative aimed at optimizing electricity consumption across South Africa by promoting energy efficiency and demand-side management among consumers, businesses, and industries. A summary of the program is provided in Table 2.5v. Its main objectives are to alleviate the strain on the national power grid, especially during peak demand periods, and to reduce overall energy consumption. By encouraging the adoption of energy-saving technologies and practices, the IDM Programme helps lower electricity demand, leading to a more stable and reliable power supply. Additionally, the reduction in energy consumption contributes to the decrease of GHG emissions, supporting South Africa's efforts to mitigate climate change and move towards a more sustainable energy future. From 2010 to 2022; the program has contributed to reducing South Africa’s GHG emissions cumulatively by 8.95 Mt CO_2-eq (shown in

Table 2.6).

Table 2.5: Eskom Integrated Demand Management (IDM) Programme

No.	Name	Description	Objectives	Type of instrument
2	Eskom Integrated Demand Management (IDM) Programme	Promotes energy efficiency and load management. The programme has promoted the implementation of energy efficiency technologies by providing various rebates for energy efficiency; management and conservation measures, as well as solar water heater installations.	Provides for the efficient use of energy resources and related incentives / rebates.	economic
Status	Sector affected	Gases affected	Start year of implementation	Implementing entity
Implemented	Energy	CO_2	2005	Eskom IDM team

Table 2.6: GHG emission reductions of the Eskom Integrated Demand Management (IDM) Programme

	Achieved	**Expected**
Year	**Emission Reduction (Mt CO_2-eq)**	
2010	0.53	
2011	1.33	
2012	1.35	
2013	1.83	
2014	1.36	
2015	0.82	
2016	0.54	FX
2017	0.54	
2018	0.13	
2019	0.13	
2020	0.13	
2021	0.13	
2022	0.13	
Total	8.95	

2.6.1.1c) Municipal Energy Efficiency and Demand Side Management programme

The South African Municipal Energy Efficiency and Demand Side Management (EEDSM) programme aims to enhance energy efficiency and manage electricity demand within municipalities. A summary of the program is provided in Table 2.7. Its main objectives are to reduce energy consumption in municipal operations, lower electricity costs, and improve the overall efficiency of municipal infrastructure such as street lighting, water pumping, and public buildings. By implementing energy-saving technologies and practices, the EEDSM programme helps municipalities decrease their electricity usage, thereby reducing the demand on the national power grid. This reduction in energy consumption leads to fewer GHG emissions from power generation, supporting South Africa's efforts to mitigate climate change and promote sustainable development. From 2010 to 2022; the program has contributed to reducing South Africa's GHG emissions cumulatively by 26.86 Mt CO_2-eq (shown in Table 2.8).

Table 2.7: Municipal Energy Efficiency and Demand Side Management programme

No.	Name	Description	Objectives	Type of instrument
3	Municipal Energy Efficiency and Demand Side Management programme	Allocation of grant funds to municipalities for the purpose of carrying out energy-efficient upgrades to their infrastructure	Facilitates the effective utilization of energy resources and offers associated incentives or rebates	Economic
Status	Sector affected	Gases affected	Start year of implementation	Implementing entity
Implemented	Energy	CO_2	2011	South African National Energy Development Institute (SANEDI)

Table 2.8: GHG emission reductions of the Municipal Energy Efficiency and Demand Side Management programme

Estimates of GHG emission reductions		
Achieved		**Expected**
Year	**Emission Reduction (Mt CO_2-eq)**	**FX**
2010	0	
2011	0.39	
2012	0.43	
2013	0.49	
2014	0.61	
2015	0.85	

2016	1.33
2017	2.26
2018	4.1
2019	4.1
2020	4.1
2021	4.1
2022	4.1
Total	26.86

2.6.1.1d)

National Cleaner Production Centre South Africa (NCPC) program

The National Cleaner Production Centre South Africa (NCPC) program is a key initiative focused on promoting cleaner production techniques and sustainable practices across various industries. A summary of the program is provided in Table 2.9. Its main objectives are to enhance resource efficiency, reduce waste, and minimize the environmental impact of industrial processes. By offering support and guidance on adopting energy-efficient technologies and waste reduction strategies, the NCPC program helps businesses improve their operational performance while lowering their environmental footprint. This leads to a reduction in energy consumption and GHG emissions, contributing significantly to South Africa's efforts to combat climate change and advance towards a more sustainable and environmentally responsible industrial sector. From 2010 to 2022; the program has contributed to reducing South Africa's GHG emissions cumulatively by 4.37 Mt CO_2-eq (shown in Table 2.10).

Table 2.9: The National Cleaner Production Centre South Africa (NCPC) program

No.	Name	Description	Objectives	Type of instrument
4	The National Cleaner Production Centre South Africa (NCPC) program	Implementation of projects within the private sector that enhance energy efficiency and boost the economic competitiveness of South African businesses by optimizing resources and processes	The action aims to facilitate energy efficiency measures, particularly in the industrial and commercial sectors, to mitigate GHG emissions related to the energy sector and stimulate job creation in the green economy.	International Agreements and Cooperation
Status	Sector affected	Gases affected	Start year of implementation	Implementing entity
Implemented	Energy	CO_2	2011	National Cleaner Production Centre

Table 2.10: GHG emission reductions of The National Cleaner Production Centre South Africa (NCPC) program

Estimates of GHG emission reductions		
Achieved		Expected
Year	Emission Reduction (Mt CO_2-eq)	
2010	0	
2011	0.09	
2012	0.22	
2013	0.59	
2014	0.59	
2015	0.6	
2016	0.07	FX
2017	0.29	
2018	0.41	
2019	0.49	
2020	0.34	
2021	0.34	
2022	0.34	
Total	4.37	

2.6.1.1e) Private Sector Energy Efficiency (PSEE) Programme

The South African Private Sector Energy Efficiency (PSEE) Programme is designed to support and incentivize businesses in adopting energy-efficient practices and technologies. A summary of the program is provided in Table 2.11. Its main objectives are to enhance energy performance, reduce operational costs, and encourage the implementation of energy-saving measures across various industries. By providing resources, technical assistance, and financial incentives, the PSEE Programme helps businesses decrease their energy consumption, which in turn reduces the demand for electricity from fossil fuel sources. This reduction in energy use leads to lower GHG emissions, supporting South Africa's broader climate goals and contributing to a more sustainable and environmentally friendly economy. From 2010 to 2022; the program has contributed to reducing South Africa's GHG emissions cumulatively by 1.35 Mt CO_2-eq (shown in Table 2.12).

Table 2.11: Private Sector Energy Efficiency (PSEE) Programme

No.	Name	Description	Objectives	Type of instrument
5	Private Sector Energy Efficiency (PSEE) Programme	Implement projects in the private sector that achieve energy savings and improved economic competitiveness in South African businesses through resource and process efficiency.	The action aims to facilitate energy efficiency measures, particularly in the industrial and commercial sectors, to mitigate greenhouse gas emissions related to the energy sector and stimulate job creation in the green economy.	International Agreements and Cooperation
Status	Sector affected	Gases affected	Start year of implementation	Implementing entity
Implemented	Energy	CO_2	2013	National Business Initiative (NBI)

Table 2.12: Estimates of GHG emission reductions of the Private Sector Energy Efficiency (PSEE) Programme

Estimates of GHG emission reductions		
Achieved		**Expected**
Year	**Emission Reduction (Mt CO_2-eq)**	FX
2010	0	

Estimates of GHG emission reductions		
Achieved		Expected
2011	0	
2012	0	
2013	0	
2014	0.15	
2015	0.15	
2016	0.14	
2017	0.14	
2018	0.14	
2019	0.15	
2020	0.16	
2021	0.16	
2022	0.16	
Total	1.35	

2.6.1.1f) Private sector embedded solar generation

Private Sector Embedded Solar Generation Initiative in South Africa encourages businesses to generate their own electricity using solar power systems installed on their premises. A summary of the program is provided in

Table 2.13. Its main objectives are to enhance energy security, reduce reliance on the national power grid, and lower electricity costs for private sector entities. By promoting the adoption of solar energy, the initiative facilitates a shift towards renewable energy sources, significantly decreasing the consumption of fossil fuels. This transition to solar power leads to a substantial reduction in GHG emissions, contributing to South Africa's efforts to combat climate change and move towards a more sustainable and low-carbon energy future. From 2010 to 2022; the program has contributed to reducing South Africa's GHG emissions cumulatively by 1.45 Mt CO_2-eq (shown in Table 2.14).

Table 2.13: Private sector embedded solar generation

No.	Name	Description	Objectives	Type of instrument
6	Private sector embedded solar generation	Installation of embedded solar PV for electricity generation.	Solar photovoltaic (PV) generation, which can be quickly deployed, is expected to be the key technology behind small-scale embedded generation.	Technology and Innovation Measures
Status	Sector affected	Gases affected	Start year of implementation	Implementing entity
Implemented	Energy	CO_2	2018	Private sector

Table 2.14: Estimates of GHG emission reductions of private sector embedded solar generation

Estimates of GHG emission reductions		
Achieved		Expected
Year	**Emission Reduction (Mt CO_2-eq)**	FX
2010	0	
2011	0	
2012	0	
2013	0	
2014	0	
2015	0	
2016	0	
2017	0	
2018	0.21	

Estimates of GHG emission reductions		
	Achieved	**Expected**
2019	0.31	
2020	0.31	
2021	0.31	
2022	0.31	
Total	1.45	

2.6.1.1g) Renewable Energy Independent Power Producer Procurement (REIPPP) programme

The South African Renewable Energy Independent Power Producer Procurement (REIPPP) programme is a government initiative aimed at increasing the country's renewable energy capacity by engaging private sector investment. A summary of the program is provided in Table 2.15. Its main objectives are to diversify the energy mix, enhance energy security, and stimulate economic growth through the development of renewable energy projects such as wind, solar, and hydro power. By facilitating the procurement of clean energy from independent power producers, the REIPPP programme significantly reduces the reliance on fossil fuels for electricity generation. This transition to renewable energy sources leads to a marked decrease in GHG emissions, supporting South Africa's efforts to mitigate climate change and achieve its environmental sustainability targets. From 2010 to 2022; the program has contributed to reducing South Africa's GHG emissions cumulatively by 101.99 Mt CO_2-eq (shown in Table 2.16).

Table 2.15: Renewable Energy Independent Power Producer Procurement (REIPPP) programme

No.	Name	Description	Objectives	Type of instrument
7	Renewable Energy Independent Power Producer Procurement (REIPPP) programme	Competitive procurement programme, where prospective power producers submit bids to supply Eskom with renewable energy. The Department of Mineral Resources and Energy adjudicates the bids according to various criteria, price being the most critical.	The Integrated Resource Plan makes provision for the generation of 17.8 GW of renewable energy by 2030, to be commissioned under the Programme.	Economic
Status	Sector affected	Gases affected	Start year of implementation	Implementing entity
Implemented	Energy	CO_2	2011	Eskom

Table 2.16: Estimates of GHG emission reductions of the Renewable Energy Independent Power Producer Procurement (REIPPP) programme

Estimates of GHG emission reductions		
Achieved		Expected
Year	Emission Reduction (Mt CO_2-eq)	FX
2010	0	
2011	0	
2012	0	
2013	0	
2014	5.21	
2015	7.01	
2016	8.91	
2017	11.81	
2018	12.81	

Estimates of GHG emission reductions		
Achieved		Expected
2019	13.31	
2020	14.31	
2021	14.31	
2022	14.31	
Total	101.99	

2.6.1.1h) Natural Gas Fuel Switch Programmes

The South African Natural Gas Fuel Switch programme is an initiative designed to promote the transition from coal and oil to natural gas as a cleaner energy source for industrial and power generation processes. A summary of the program is provided in Table 2.17. Its main objectives are to reduce GHG emissions, improve air quality, and enhance energy efficiency. By encouraging industries to adopt natural gas, which burns more cleanly and efficiently than coal and oil, the programme aims to lower carbon dioxide and other harmful emissions. This shift helps to mitigate climate change, as natural gas produces significantly fewer GHGs compared to traditional fossil fuels, supporting South Africa's efforts to reduce its carbon footprint and advance towards a more sustainable energy future. From 2010 to 2022; the program has contributed to reducing South Africa’s GHG emissions cumulatively by 97.73 Mt CO_2-eq (shown in

Table 2.18).

Table 2.17: Natural Gas Fuel Switch Programmes

No.	Name	Description	Objectives	Type of instrument
8	Natural Gas Fuel Switch Programmes	Switch to natural gas from emission intensive fuels.	To provide an economical and eco-friendly energy, by supplying natural gas to Compressed Natural Gas (CNG) refuelling stations, gas distribution networks, industries and power generation systems and to customers who are not on the existing gas network. CNG is transported by road to customers not on the existing gas pipeline and CNG equipment, advice and support provided to help industrial users and transport owners convert	Technology and Innovation Measures
Status	Sector affected	Gases affected	Start year of implementation	Implementing entity
Implemented	Energy	CO_2	2000	Department of Mineral Resources and Energy

Table 2.18: Estimates of GHG emission reductions of Natural Gas Fuel Switch Programmes

Estimates of GHG emission reductions		
Achieved		Expected
Year	**Emission Reduction (Mt CO_2-eq)**	
2010	7.66	
2011	7.35	
2012	7.37	
2013	6.95	
2014	7.74	
2015	7.78	
2016	7.08	FX
2017	7.08	
2018	7.08	
2019	7.91	
2020	7.91	
2021	7.91	
2022	7.91	
Total	97.73	

2.6.1.2 Transport

2.6.1.2a) Bus Rapid Transport (BRT) System

The South African Bus Rapid Transit (BRT) programme, funded through the Public Network Transport Grant, aims to improve urban public transportation by developing efficient, high-capacity bus networks in major cities. Its main objectives are to reduce traffic congestion, enhance mobility, and provide reliable and affordable public transport options. A summary of the program is provided in Table 2.19. The purpose of the Public Network Transport Grant is to support the National Land Transport Act (Act No. 5 of 2009) and the Public Transport Strategy (PTS) and Action Plan in advancing the delivery of accessible, reliable, and affordable integrated municipal public transport services. Functional BRT systems have been implemented in cities such as Johannesburg (Rea Vaya), Cape Town (MyCiTi), and Pretoria (A Re Yeng).

By prioritizing bus lanes and streamlining routes, the BRT programme encourages more people to use public transportation instead of private vehicles. This shift reduces the number of cars on the road, leading to lower fuel consumption and a significant decrease in GHG emissions. Consequently, the BRT programme helps mitigate climate change, promotes sustainable urban development, and improves air quality in South African cities. From 2010 to 2022; the program has contributed to reducing South Africa's GHG emissions cumulatively by 0.63 Mt CO_2-eq (shown in

Table 2.20).

Table 2.19: Bus Rapid Transport (BRT) System

No.	Name	Description	Objectives	Type of instrument
9	Bus Rapid Transport (BRT) System	An urban public transportation initiative aimed at improving the efficiency, reliability, and affordability of bus services in major cities. Funded through the Public Network Transport Grant, the program focuses on developing high-capacity bus networks with dedicated lanes, streamlined routes, and modern infrastructure.	Its main objectives are to reduce traffic congestion, enhance mobility, and provide accessible public transport options for all citizens	Economic
Status	Sector affected	Gases affected	Start year of implementation	Implementing entity
Implemented	Energy	CO_2	2007	DoT

Table 2.20: Estimates of GHG emission reductions of the Bus Rapid Transport (BRT) System

Estimates of GHG emission reductions		
Achieved		**Expected**
Year	**Emission Reduction (Mt CO_2-eq)**	
2010	0	
2011	0	
2012	0.05	
2013	0.05	
2014	0.05	
2015	0.05	
2016	0.05	**FX**
2017	0.05	
2018	0.05	
2019	0.07	
2020	0.07	
2021	0.07	
2022	0.07	
Total	0.63	

2.6.1.2b) Transnet Road-to-Rail Programme

The Transnet Road-to-Rail Programme is an initiative aimed at shifting freight transportation from road to rail networks. Its main objectives are to alleviate road congestion, reduce road maintenance costs, and enhance the efficiency and reliability of the country's freight transport system. A summary of the program is provided in

Table 2.21. By promoting the use of rail for transporting goods, the programme significantly reduces the number of heavy trucks on the roads, which in turn decreases fuel consumption and lowers GHG emissions. This transition not only helps mitigate climate change but also contributes to improved air quality and a reduction in the environmental impact of freight transport in South Africa. From 2010 to 2022; the program has contributed to reducing South Africa's GHG emissions cumulatively by 3.2 Mt CO_2-eq (shown in Table 2.22).

Table 2.21: Transnet Road-to-Rail Programme

No.	Name	Description	Objectives	Type of instrument
10	Transnet Road-to-Rail Programme	The Programme is designed to shift freight transportation from road to rail, aiming to enhance rail infrastructure and reduce road congestion. By increasing the use of rail for cargo transport, the programme seeks to lower transportation costs, improve logistics efficiency, and decrease GHG emissions, supporting the country's climate goals and promoting more sustainable transport solutions.	The main objectives of the Transnet Road-to-Rail Programme are to enhance rail infrastructure and shift freight transportation from road to rail. This shift aims to reduce road congestion, lower transportation costs, and decrease greenhouse gas emissions, supporting more sustainable and efficient transport solutions.	Other
Status	Sector affected	Gases affected	Start year of implementation	Implementing entity
Implemented	Energy	CO_2	2012	Transet

Table 2.22: Estimates of GHG emission reductions of the Transnet Road-to-Rail Programme

Estimates of GHG emission reductions		
Achieved		**Expected**
Year	Emission Reduction (Mt CO_2-eq)	FX
2010	0	
2011	0	
2012	0	
2013	0	
2014	0.48	
2015	0.31	

Estimates of GHG emission reductions		
Achieved		**Expected**
2016	0.64	
2017	0.86	
2018	0.11	
2019	0.2	
2020	0.32	
2021	0.2	
2022	0.08	
Total	3.2	

2.6.1.3 IPPU

2.6.1.3a) Nitrous Oxide Reduction Projects

South Africa's N_2O Reduction Projects typically involve the implementation of advanced technologies and process modifications to capture and convert N_2O into less harmful substances. A summary of the program is provided in

Table 2.23. Techniques such as catalytic decomposition, where specialized catalysts break down N_2O into nitrogen and oxygen, and the integration of emission control systems are common. By reducing N_2O emissions, these initiatives aim to lower the environmental impact of nitric acid production, contribute to improved air quality, and support South Africa's climate goals by reducing greenhouse gas emissions. From 2010 to 2022; the program has contributed to reducing South Africa’s GHG emissions cumulatively by 16.92 Mt CO_2-eq (shown in Table 2.24).

Table 2.23: Nitrous Oxide Reduction Projects

No.	Name	Description	Objectives	Type of instrument
11	Nitrous Oxide Reduction Projects	The Projects in nitric acid production focus on minimizing N_2O emissions through advanced technologies and process improvements. These initiatives typically involve implementing catalytic decomposition systems to convert N_2O into less harmful substances, thereby reducing the environmental impact and supporting the country's climate goals.	To significantly lower N2O emissions by employing advanced control technologies and process enhancements. These efforts aim to reduce the environmental impact of nitric acid production and contribute to the country's climate change mitigation goals.	Other
Status	Sector affected	Gases affected	Start year of implementation	Implementing entity
Implemented	Energy	N_2O	2006	Private sector

Table 2.24: Estimates of GHG emission reductions of Nitrous Oxide Reduction Projects

Estimates of GHG emission reductions		
Achieved		**Expected**
Year	**Emission Reduction (Mt CO_2-eq)**	FX
2010	0	
2011	1.46	
2012	1.71	
2013	1.69	
2014	1.69	
2015	1.69	
2016	1.69	

Estimates of GHG emission reductions		
Achieved		**Expected**
2017	1.63	
2018	1.2	
2019	1.04	
2020	1.04	
2021	1.04	
2022	1.04	
Total	16.92	

2.6.1.4 Agriculture

2.6.1.4a) Conservation Agriculture

Conservation agriculture practices are promoted as part of Comprehensive Agricultural Support Programme (CASP); Ilima/Letsema Projects; Land Care Programme and the Working for Land Programme. These practices focus on sustainable farming techniques such as minimal soil disturbance, cover cropping, and crop rotation to improve soil health, enhance water retention, and increase agricultural productivity. A summary of the conservation agriculture measure is provided in Table 2.25. The aim of the grant funded programs are to promote sustainable land management and job creation through community-based initiatives that support social, economic, and environmental sustainability. This involves assisting vulnerable South African farming communities to boost agricultural production and invest in critical infrastructure. By providing coordinated agricultural support and collaborating with industry initiatives, these programs enhance food productivity and supports land reform beneficiaries. By adopting conservation agriculture, South Africa aims to reduce GHG emissions through enhanced carbon sequestration in soils, decreased reliance on chemical inputs, and improved overall farm resilience, contributing to the country's climate change mitigation efforts. The grant programs also aim to revitalize agricultural colleges into centres of excellence and incentivizes provincial departments to create jobs through labour-intensive methods in areas like road maintenance, building upkeep, tourism, and waste management. From 2010 to 2022; conservation agriculture practices have contributed to reducing South Africa's GHG emissions cumulatively by 13,34 Mt CO_2-eq (shown in Table 2.26).

Table 2.25: Conservation Agriculture

No.	Name	Description	Objectives	Type of instrument
12	Conservation Agriculture	Grant funded projects which focus on sustainable farming practices that improve soil health, water conservation, and crop productivity.	To advance sustainable farming practices, improve soil and water management, and support rural development and environmental stewardship	Economic
Status	Sector affected	Gases affected	Start year of implementation	Implementing entity
Implemented	Agriculture	CO_2; CH_4; N_2O	2001	Department of Agriculture

Table 2.26: Estimates of GHG emission reductions of Conservation Agriculture

Estimates of GHG emission reductions		
Achieved		Expected
Year	Emission Reduction (Mt CO_2-eq)	FX
2010	0,64	
2011	0,69	

Estimates of GHG emission reductions		
Achieved		Expected
2012	0,74	
2013	0,8	
2014	0,86	
2015	0,92	
2016	0,99	
2017	1,06	
2018	1,14	
2019	1,23	
2020	1,32	
2021	1,42	
2022	1,53	
Total	13,34	

2.6.1.4b) Grassland Restoration

The implementation of grassland restoration is guided by several key commitments and programs. It aligns with the United Nations Convention to Combat Desertification (UNCCD) medium-term goal to rehabilitate and sustainably manage 2,436,170 hectares of grassland by 2030. Additionally, it supports the natural land cover restoration objectives outlined in the National Biodiversity Strategy and Action Plan (NBSAP). This effort is further bolstered by the DFFE "Working for" programs, which focus on restoring ecological infrastructure, and the Department of Agriculture Land Care Programs, which emphasize sustainable land management in agricultural areas. A summary of the grassland restoration measure is provided in Table 2.28. Grassland restoration reduces GHG emissions by enhancing carbon sequestration in soils and vegetation, improving soil health, and preventing soil erosion and land degradation. From 2010 to 2022; grassland restoration activities have contributed to

Table 2.27: Reducing South Africa's GHG emissions cumulatively by 13.95 Mt CO_2-eq (shown in Table 2.28).

Table 2.27: Grassland Restoration

No.	Name	Description	Objectives	Type of instrument
13	Grassland Restoration	Grassland restoration aims to enhance the productivity of grasslands by encouraging sustainable grazing practices that minimize topsoil loss and disruption, boost forage production and coverage, and preserve the diversity of essential forage species.	To restore and rehabilitate grasslands and grazing lands while reducing soil erosion	Regulatory measures
Status	Sector affected	Gases affected	Start year of implementation	Implementing entity
Implemented	Agriculture	CO_2; CH_4; N_2O	2001	Department of Agriculture; DFFE

Table 2.28: Estimates of GHG emission reductions of Grassland Restoration

Estimates of GHG emission reductions		
Achieved		Expected
Year	Emission Reduction (Mt CO_2-eq)	FX
2010	1,18	
2011	1,21	
2012	1,21	
2013	1,22	
2014	1,22	

Estimates of GHG emission reductions		
Achieved		Expected
2015	0,41	
2016	0,41	
2017	0,4	
2018	0,45	
2019	1,55	
2020	1,55	
2021	1,56	
2022	1,58	
Total	13,95	

2.6.1.5 Forestry

Forestland management, including natural forests and plantations and the afforestation and restoration activities thereof, is regulated by the National Forests Act, 1998 (Act No. 84 of 1998). This Act emphasizes sustainable forest management and outlines how forests can be used by people and communities without causing destruction. Additionally, the National Veld and Forest Fire Act, 1998 (Act No. 101 of 1998) is crucial for managing forest fires and ensuring fire safety.

These laws are supported by various amendments and policies, such as the Forestry Laws Amendment Act, 2005 (Act No. 35 of 2005) and the National Forest and Fire Laws Amendment Act, 2001 (Act No. 12 of 2001). Together, they provide a comprehensive framework for the sustainable management and protection of South Africa’s forest resources

The National Forests Amendment Act, 2022 aims to enhance forest management and protection by clarifying definitions, establishing public trusteeship, promoting sustainability, controlling deforestation, reinforcing penalties, and providing an appeals process. The proposed 2023 amendment reinforces the appeals mechanism for provisions for appeals against delegated decisions, the formation of an appeals committee, specific timeframes for lodging and deciding appeals, and measures to ensure transparency and fairness, all aimed at enhancing accountability and fairness in forest management.

2.6.1.5a) Afforestation

The afforestation programs managed by DFFE, including the Working for Land and Working for Ecosystems initiatives, focus on expanding and restoring forested areas to enhance environmental sustainability and ecosystem health. A summary of the measure is provided in Table 2.29. The main objectives of these programs are to increase forest cover, improve biodiversity, and rehabilitate degraded landscapes. By doing so, these initiatives help reduce South Africa's GHG emissions by sequestering carbon dioxide in vegetation and soil, improving overall carbon storage, and mitigating the effects of climate change. From 2010 to 2022; afforestation activities have contributed to reducing South Africa's GHG emissions cumulatively by 352,24 Mt CO_2-eq (shown in

Table 2.30).

*Table 2.29**:** Afforestation*

No.	Name	Description	Objectives	Type of instrument
14	Afforestation	The afforestation programs managed by the Department of Forestry, Fisheries, and the Environment, including the Working for Land and Working for Ecosystems initiatives, focus on expanding and restoring forested areas to enhance environmental sustainability and ecosystem health.	To increase and rehabilitate forested regions in order to boost environmental sustainability, enrich biodiversity, and strengthen ecosystem health.	Regulatory measures
Status	Sector affected	Gases affected	Start year of implementation	Implementing entity

No.	Name	Description	Objectives	Type of instrument
Implemented	Energy	CO_2	2006	DFFE

Table 2.30: Estimates of GHG emission reductions of Afforestation

Estimates of GHG emission reductions		
Achieved		Expected
Year	Emission Reduction (Mt CO_2-eq)	
2010	17,24	
2011	18,07	
2012	20,21	
2013	21,64	
2014	18,72	
2015	21,6	
2016	26,62	FX
2017	24,48	
2018	24,67	
2019	31,45	
2020	38,56	
2021	40,15	
2022	48,83	
Total	352,24	

2.6.1.5b) Forest and Woodland Restoration and Rehabilitation

The forest and woodland restoration and rehabilitation activities managed DFFE, including as part of the Working for Land and Working for Ecosystems initiatives, focus on revitalizing degraded forest and woodland areas to restore ecological balance and enhance environmental quality. A summary of the measure is provided in

Table 2.31. The primary objectives are to rehabilitate damaged landscapes, increase biodiversity, and improve carbon sequestration. By expanding forest cover and improving the health of these ecosystems, these activities contribute to reducing South Africa's GHG emissions through enhanced carbon capture and storage, while also supporting overall climate resilience and ecological sustainability. From 2010 to 2022; forest and woodland restoration and rehabilitation activities have contributed to reducing South Africa's GHG emissions cumulatively by 50.96 Mt CO2-eq (shown in Table 2.32).

Table 2.31: Forest and Woodland Restoration and Rehabilitation

No.	Name	Description	Objectives	Type of instrument
15	Forest and Woodland Restoration and Rehabilitation	As part of the Department of Forestry, Fisheries, and the Environment's Working for Land and Working for Ecosystems initiatives, the actions aim to restore degraded landscapes, enhance biodiversity, and improve carbon sequestration to support ecological balance and mitigate climate change.	To rehabilitate degraded landscapes, boost biodiversity, and improve carbon capture to strengthen ecological health and climate resilience.	Regulatory measures

No.	Name	Description	Objectives	Type of instrument
Status	Sector affected	Gases affected	Start year of implementation	Implementing entity
Implemented	Energy	CO_2	2006	DFFE

Table 2.32: Estimates of GHG emission reductions of Forest and Woodland Restoration and Rehabilitation

Estimates of GHG emission reductions		
Achieved		Expected
Year	Emission Reduction (Mt CO_2-eq)	FX
2010	1.92	
2011	2.23	
2012	2.55	
2013	2.98	
2014	2.28	
2015	2.88	
2016	4.03	
2017	3.25	
2018	2.96	
2019	5.13	
2020	6.48	
2021	6.23	
2022	8.04	
Total	50.96	

2.6.1.6 Other Land Uses

The Biodiversity Act of 2004 in South Africa supports the restoration and afforestation of natural landscapes through conservation and sustainable use, ecosystem protection, biodiversity management plans, incentives for landowners, and monitoring and enforcement mechanisms. The National Biodiversity Framework serves as an implementation tool for the National Environmental Management: Biodiversity Act and outlines specific outcomes to achieve biodiversity conservation. The NBSAP provides a strategic framework for biodiversity management, which is operationalized through the National Biodiversity Framework (NBF) as mandated by Chapter 3 of the Biodiversity Act.

2.6.1.6a) Thicket Restoration

Thick restoration is driven by several key commitments and programs. A summary of the measure is provided in

Table 2.33. It aligns with the medium-term (2030) UNCCD commitment to combat desertification by rehabilitating and sustainably managing 87,621 hectares of thicket. Additionally, it supports natural land cover restoration goals outlined in the National Biodiversity Strategy and Action Plan (NBSAP). The Department of Forestry, Fisheries, and the Environment's "Working for" programs focus on restoring ecological infrastructure, while the Department of Agriculture, Land Reform, and Rural Development's Land Care programs emphasize sustainable land management in agricultural areas. quality.

Thicket restoration helps reduce GHG emissions by enhancing carbon sequestration, as restored thickets absorb and store carbon dioxide in their biomass and soil. Additionally, healthy thickets improve soil quality and stability, reducing the release of carbon stored in the soil and minimizing soil erosion. Overall, thicket restoration contributes to a more resilient and sustainable ecosystem that plays a crucial role in reducing the country's GHG emissions. From 2010 to 2022; thicket restoration activities have contributed to reducing South Africa’s GHG emissions cumulatively by 16.08 Mt CO_2-eq (shown in Table 2.34).

Table 2.33: Thicket Restoration

No.	Name	Description	Objectives	Type of instrument
16	Thicket Restoration	Thicket restoration activities in South Africa focus on rehabilitating degraded thicket ecosystems to enhance biodiversity, improve soil quality, and increase carbon sequestration, thereby supporting environmental sustainability and climate change mitigation.	The main objective of thicket restoration in South Africa is to rehabilitate degraded thicket ecosystems involving the replanting of thicket vegetation to enhance biodiversity and improve ecological health, with the purpose of increasing carbon sequestration and thereby reducing GHG emissions.	Regulatory measures
Status	Sector affected	Gases affected	Start year of implementation	Implementing entity
Implemented	Energy	CO_2	2006	DFFE; Department of Agriculture

Table 2.34: Estimates of GHG emission reductions of Thicket Restoration

Estimates of GHG emission reductions		
Achieved		Expected
Year	Emission Reduction (Mt CO_2-eq)	FX
2010	1.1	
2011	1.2	
2012	1.11	
2013	1.19	
2014	1.11	
2015	1.29	
2016	1.41	
2017	1.32	

Estimates of GHG emission reductions		
Achieved		Expected
2018	1.3	
2019	1.37	
2020	1.38	
2021	1.12	
2022	1.18	
Total	16.08	

2.6.1.5b) Shrubland restoration and afforestation

Shrubland exists in South Africa distributed in the Northern Cape, Western Cape and Eastern Cape. Smaller areas of karroid type shrubland exists in other interior provinces such as Northwest and Free State. A summary of the measure is provided in Table 2.35. Shrubland restoration and afforestation aligns with the medium-term (2030) UNCCD commitment to combat desertification by rehabilitating and sustainably managing 1 349 714 ha of fynbos; 149 877 ha of Succulent Karoo and 528 632 ha of Nama Karoo. The restoration and afforestation of shrubland align with the National Biodiversity Framework (2019-2024) and the National Biodiversity Strategy and Action Plan (2015-2025) by promoting ecosystem restoration, enhancing climate resilience, protecting biodiversity, and supporting sustainable land use. The Working for Ecosystems programme, under the DFFE, focuses on restoring degraded landscapes through ecosystem rehabilitation and invasive alien species control, particularly in Karroid regions. Similarly, the Working for Water Programme targets the removal of invasive alien species that degrade water resources and ecosystems, including those affecting Karroid vegetation in arid regions, thereby helping to restore natural shrublands, enhance water availability, and improve biodiversity.

The restoration and afforestation of shrubland vegetation help reduce South Africa's GHG emissions by enhancing carbon sequestration in arid and semi-arid regions. Restored shrublands capture and store carbon in plant biomass and soils, which can mitigate emissions from other sectors. Additionally, restoration prevents further land degradation, reducing the release of carbon stored in soils. From 2010 to 2022;

restoration and afforestation of shrubland has contributed to reducing South Africa's GHG emissions cumulatively by 11,77 Mt CO_2-eq (shown in

Table 2.36).

Table 2.35: Shrubland Restoration and Afforestation

No.	Name	Description	Objectives	Type of instrument
17	*Shrubland Restoration and Afforestation*	Initiatives that are a part of the Department of Forestry, Fisheries, and the Environment's policy and programmes which focus on rehabilitating degraded shrublands, improving soil fertility, and restoring vegetation cover to prevent further degradation	For the Karoo, objectives include restoring degraded landscapes, enhancing soil and water management, and promoting sustainable land use to improve ecosystem health and carbon sequestration, while for the Fynbos, the goals are to conserve biodiversity, protect high-biodiversity areas, restore degraded lands, integrate biodiversity into land use planning, and enhance ecosystem resilience to climate change.	Regulatory measures
Status	Sector affected	Gases affected	Start year of implementation	Implementing entity
Implemented	Energy	CO2	2006	DFFE

Table 2.36: Estimates of GHG emission reductions of Shrubland Restoration and Afforestation

Estimates of GHG emission reductions		
Achieved		Expected
Year	Emission Reduction (Mt CO_2-eq)	
2010	0.85	
2011	0.87	
2012	0.82	
2013	0.93	
2014	0.95	
2015	0.65	
2016	0.67	FX
2017	0.67	
2018	0.74	
2019	1.24	
2020	1.18	
2021	1.09	
2022	1.11	
Total	11.77	

2.6.1.7 Waste

2.6.1.7a) Municipal Landfill Gas Destruction

Municipal Landfill Gas Destruction in South Africa, as mentioned in the National Waste Management Strategy of 2020 and regulated by the National Environmental Management: Waste Act of 2008: National Standards for the extraction, flaring or recovery of landfill gas 2013, focuses on capturing and destroying CH_4 emissions from landfills to mitigate GHG emissions and reduce environmental impact. A summary of the measure is provided in Table 2.37. The strategy promotes the installation of landfill gas extraction and flaring systems, encouraging municipalities to adopt these technologies to improve waste management practices. By converting landfill gas into energy, the initiative also supports renewable energy development and contributes to South Africa's broader climate change mitigation goals. From 2010 to 2022; municipal landfill gas destruction activities have contributed to reducing South Africa’s GHG emissions cumulatively by 3.39 Mt CO_2-eq (shown in

Table 2.38).

Table 2.37: Municipal Landfill Gas Destruction

No.	Name	Description	Objectives	Type of instrument
18	Municipal Landfill Gas Destruction	Municipal landfill gas extraction and flaring activities in South Africa involve capturing methane emissions from landfills and burning them to reduce GHG emissions and environmental impact	The capturing and safe destruction of methane from landfills, thereby mitigating climate change and minimizing the environmental impact of waste disposal.	Regulatory measures
Status	Sector affected	Gases affected	Start year of implementation	Implementing entity
Implemented	Energy	CO_2	2008	DFFE

Table 2.38: Estimates of GHG emission reductions of Municipal Landfill Gas Destruction

Estimates of GHG emission reductions		
Achieved		Expected
Year	Emission Reduction (Mt CO_2-eq)	
2010	0	
2011	0.07	
2012	0.18	
2013	0.25	
2014	0.29	
2015	0.32	
2016	0.32	FX
2017	0.33	
2018	0.33	
2019	0.33	
2020	0.33	
2021	0.32	
2022	0.32	
Total	3.39	

2.6.1.7b) National Waste Management Strategy (NWMS)

The NWMS establishes a cohesive strategy and framework for enacting the Waste Act, detailing the government's policy and strategic approach to waste management. The primary aim of the strategy (DFFE; 2020) is to create a sustainable, efficient, and inclusive waste management system that minimizes environmental impact, promotes socio-economic development, and transitions towards a circular economy. The NWMS 2020 addresses key waste management issues by providing a service delivery model based on the waste management hierarchy, with specific objectives, actions, and targets for different waste streams. This includes promoting alternatives to landfilling, composting, and energy recovery, encouraging sustainable product design and packaging, advancing residential separation at source programs, and supporting the development of skills in the waste sector. It also aims to strengthen the role of waste pickers, align enforcement responsibilities, support local governments in implementing integrated waste management plans, and coordinate a comprehensive public awareness program. A summary of the NWMS is provided in Table 2.39.

Between 2010 and 2021; the NWMS has helped cumulatively reduce GHG emissions by 8.49 Mt CO_2-eq (Shown in Table 2.40) through several initiatives: promoting waste minimization, enhancing recycling and reuse, encouraging composting and energy recovery, supporting sustainable product design, facilitating residential separation at source, integrating waste pickers into the formal system, developing waste management infrastructure, and raising public awareness. These efforts collectively reduce the amount of waste in landfills, lower methane emissions, and decrease the carbon footprint of production and disposal processes.

Table 2.39: National Waste Management Strategy

No.	Name	Description	Objectives	Type of instrument
19	Waste Management Strategy	The South African National Waste Management Strategy (NWMS) 2020 is a comprehensive framework designed to guide the country's efforts in managing waste sustainably and effectively. The strategy builds on previous versions, aiming to address current challenges and align with	Promote waste minimization, reuse, recycling, and recovery. Ensure effective and efficient delivery of waste services. Enhance the waste sector's contribution to the green economy. Raise awareness about the impact of waste on health, well-being, and the environment. Achieve integrated waste management planning. Ensure sound budgeting and financial management for waste services.	Other

No.	Name	Description	Objectives	Type of instrument
		international best practices	Provide measures for the remediation of contaminated land. Establish effective compliance with and enforcement of the Waste Act.	
Status	Sector affected	Gases affected	Start year of implementation	Implementing entity
Implemented	Energy	CH4	2011	DFFE

Table 2.40: GHG emission reductions of the National Waste Management Strategy

Estimates of GHG emission reductions		
Achieved		Expected
Year	Emission Reduction (Mt CO_2-eq)	FX
2010	0.61	
2011	0.81	
2012	0.97	
2013	1.05	
2014	1.09	
2015	1.11	
2016	1.12	
2017	0.92	
2018	0.69	
2019	0.06	
2020	0.02	
2021	0.02	
2022	0.02	
Total	8.49	

2.6.1.8 How actions, policies and measures are modifying longer-term trends in GHG emissions and removals

From 2010 to 2022, the reductions in GHG emissions from current policies and measures (PAMs), excluding those related to LULUCF, averaged 5% of the national GHG emissions excluding LULUCF. As shown in Figure 2.8; GHG emission reductions excluding FOLU related ones increase from 10.01 Mt CO_2-eq in 2010 to 32.46 Mt CO_2-eq in 2022.

From 2010 to 2022, the reductions in GHG emissions from current policies and measures (PAMS), including those related to FOLU, averaged 11% of the national GHG emissions including LULUCF. As shown in Figure 2.9; GHG emission reductions including those related to FOLU increase from 30.88 Mt CO_2-eq in 2010 to 90.85 Mt CO_2-eq in 2022.

There is a declining trend of total GHG emissions from 2010 to 2022; for both indicators national GHG emissions including LULUCF and national GHG emissions excluding LULUCF. This is due to the impact of load shedding in the country which is linked to the lower coal quantities combusted at coal fired power plants.

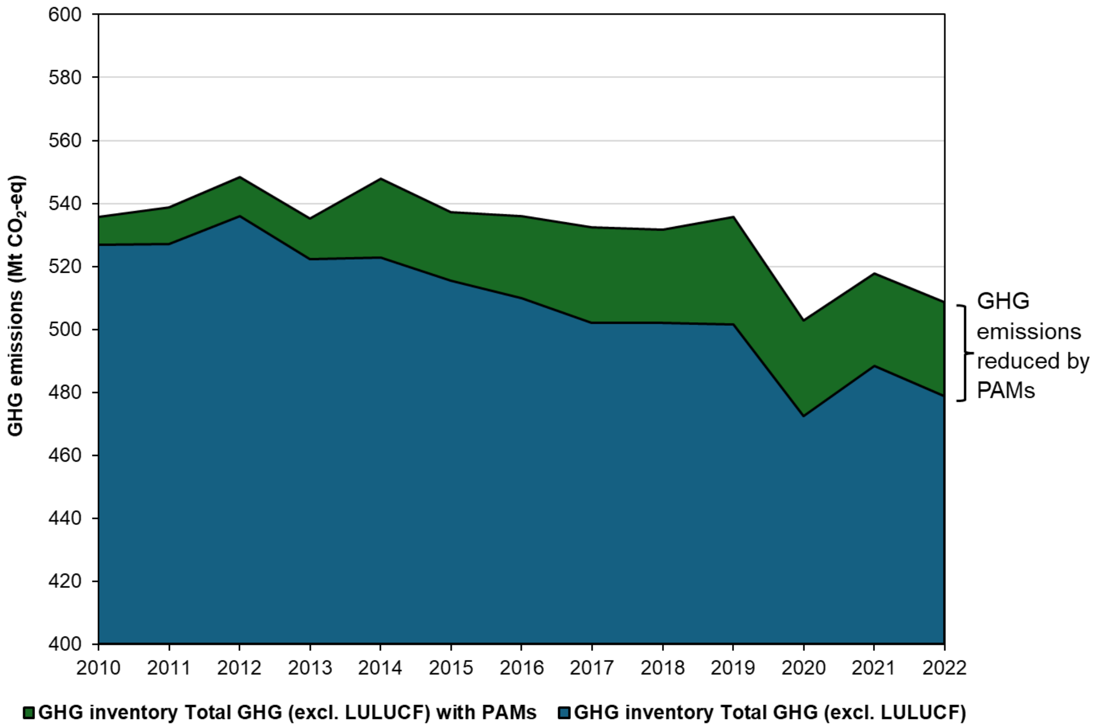

Figure 2.8: Mitigation contribution to total GHG emissions excluding LULUCF from 2010 to 2020

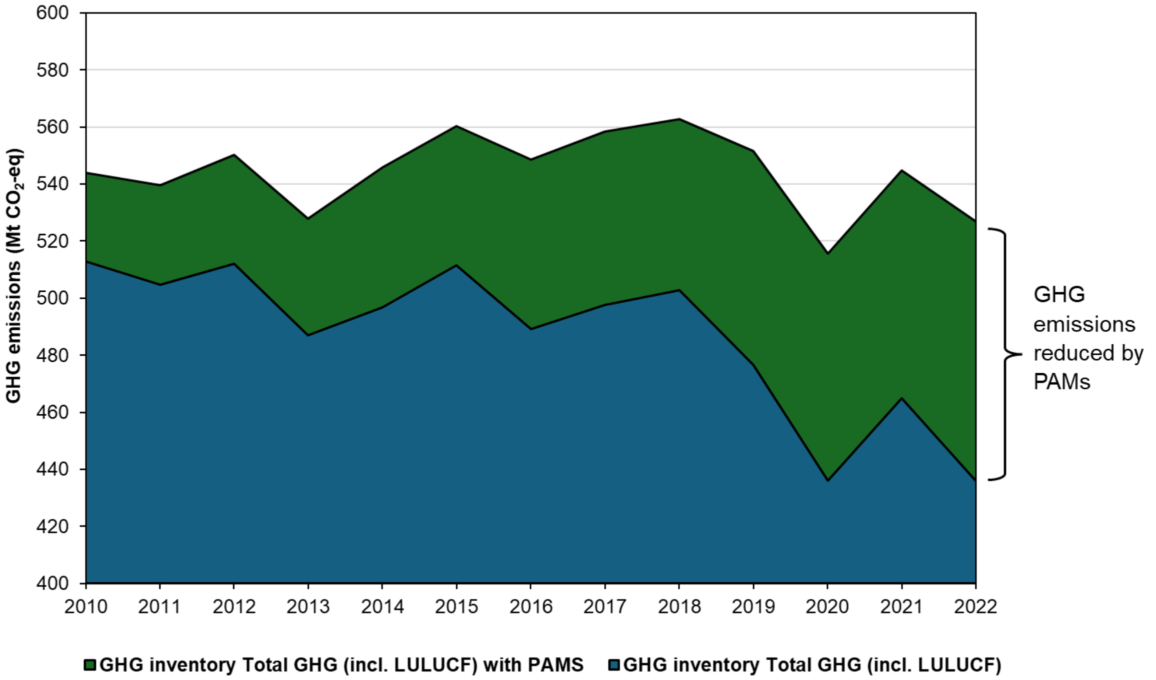

Figure 2.9: Mitigation contribution to total GHG emissions including LULUCF from 2010 to 2020

2.7 Summary of greenhouse gas emissions and removals

As provided for in Chapter 1.

2.8 Projections of greenhouse gas emissions and removals

GHG emissions are projected for a ‘with measures’ scenario for the period 2022 to 2030. In Figure 2.10 shown below, the projection of GHG emissions is shown for total GHG emissions including LULUCF and total GHG emissions without LULUCF.

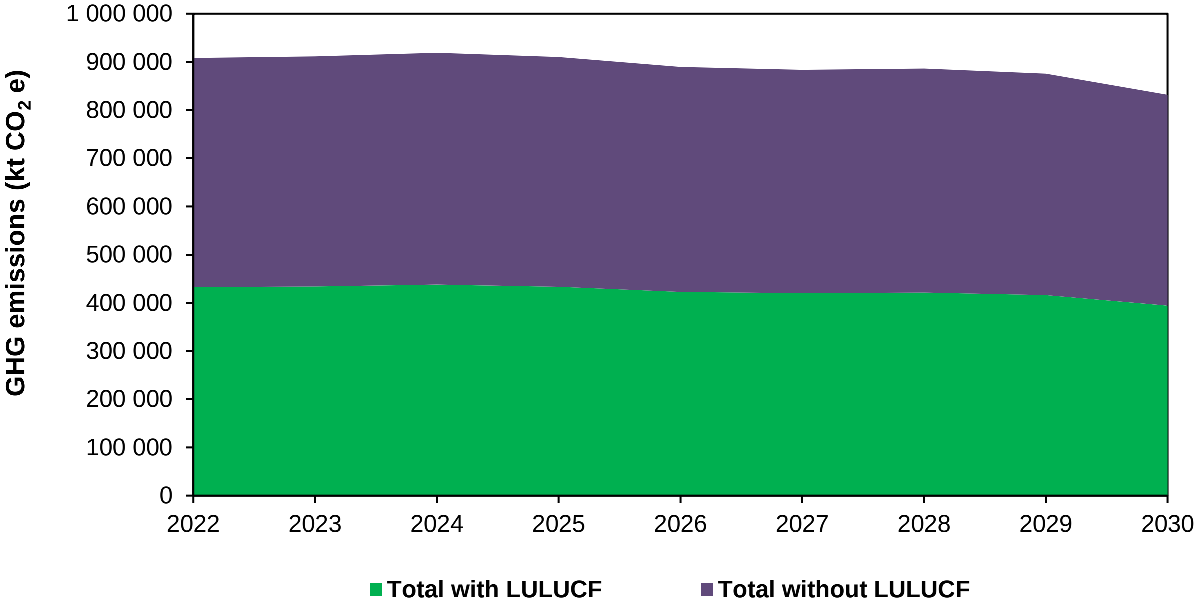

Figure 2.10: A 'with measures' Projection of Greenhouse Gas Emissions and Removals 2022 - 2030

2.8.1 Models and/or approaches used, and key underlying assumptions and parameters used for projections

The Analytica based integrated assessment DFFE Integrated Climate Change Mitigation Model has been used to quantify GHG emission projections for South Africa up to 2050. This model builds on historical activity data and integrates assumptions about emission drivers and mitigation strategies.

Incorporating earlier studies like the Mitigation Potential Analysis (MPA), South Africa's Greenhouse Gas (GHG) Emission Pathways, the Policies and Measures (PAMs) model, and Ex-post tools, the integrated model updates both historical data and assumptions. The historical data spans from 2000 to 2022, and the assumptions include the country's existing and potential climate and non-climate policies, economic developments, new scientific findings, and technological advances.

Using a bottom-up approach, the model estimates GHG emissions by considering activity data and mitigation potential in key economic sectors. It employs two linked economic models. The first is a social accounting matrix (SAM) within the Analytica framework, which evaluates the socio-economic implications of individual mitigation options. The second is an external socio-economic model developed by Cambridge Econometrics, linked to the integrated model, assessing the socio-economic impacts of mitigation strategies across different sectors and the entire economy. Additionally, the model incorporates multi-criteria assessments (MCA) to evaluate the socio-economic, environmental, and practical aspects of each mitigation option.

The socio-economic model complements the DFFE's integrated energy model by estimating the economic impacts of various energy pathways on South Africa's economy at national, industry, and household levels. It uses a simulation approach to project outcomes based on policy changes and integrates seamlessly with the Analytica energy model. The model focuses on minimizing costs under constraints and projecting outcomes based on variable relationships. Using the SAM, it links industries, products, households, and labour types for detailed scenario analysis. The model considers factors like uncertainty, market frictions, and economic capacity, and is demand-driven. Data exchange between the socio-economic and Analytica models enriches the analysis. Econometric estimations and error correction models help understand relationships between employment, wages, investment, and prices. Key economic indicators, such as sectoral output, employment, and household consumption, are calculated to provide insights into the socio-economic impacts of decarbonization pathways, aiding policymakers in understanding the broader implications of energy policies on the economy, employment, and income distribution.

Historic population data was updated to reflect the most recent historical population dataset from 2002 to 2022 The population projections were revised during the update of the MPA in 2021, with the medium scenario updated in 2024 to align with the IRP 2023. These population projections are assumed to follow the United Nations population projection from its Population Division.

2.9 Other information

2.9.1 Application of flexibility provision; planned improvements and capacity constraints related to reporting of mitigation policies and measures, actions and plans

Flexibility is applied in accordance with paragraph 85 of the MPGs to report estimates of achieved emission reductions of PAMs. The estimates of expected GHG emission reductions of current PAMs are not included in BTR1 and is a capacity constraint. However, moving forward, it is anticipated that the reporting of expected GHG emissions from current PAMs will align with the timelines for setting Sectoral Emission Targets (SETs).

Projections of GHG emissions reductions are modelling output components of the DFFE Integrated Climate Change Mitigation Model. Updates to the model that are aligned with the 2022 NIR are expected to be finalized within the next year as part of finalization of the draft SETs.

Projections of GHG emissions reductions are modelling output components of the DFFE Integrated Climate Change Mitigation Model. Updates to the model that are

aligned with the 2022 NIR are expected to be finalized within the next year as part of finalization of the draft SETs.

2.9.2 Application of flexibility provision; planned improvements and capacity constraints related to the reporting of GHG emission projections

Flexibility is applied in accordance with paragraph 92 of the MPGs, pursuant to paragraph 94. This BTR includes a ‘with measures’ projection of all GHG emissions and removals. However, it does not include a ‘with additional measures’ projection or a ‘without measures’ projection which is a capacity constraint. Updates to the integrated assessment model, aligned with the 2022 NIR used for developing projections, are expected to be finalized within the next year. These updates are linked to the finalization of the SETs, which are currently in draft form.

Flexibility is also applied in accordance with paragraphs 92 and 95 of the MPGs, pursuant to paragraph 95. GHG projections are reported up to the end point of the NDC, which is 2030. South Africa is currently unable to report GHG projections beyond this point due to capacity constraints.

The information presented in BTR1 addresses the reporting requirement to provide projections of key indicators as well as for the national total, using a common metric consistent with the NIR.

Flexibility is applied as per paragraph 102 of the MPGs pursuant to paragraph 96 of the MPGs. The methodologies used to develop the projections and the underlying models, assumptions and parameters are reported. Further detailed reporting of methodologies for projections are planned to be included in BTR2 once the draft SETs report is finalised. The reporting of sensitivity analysis for the “with measures” scenario and the methodologies and parameters used cannot be reported in this BTR and is a capacity constraint.

Flexibility is applied as per paragraph 92 of the MPGs pursuant to paragraph 98 of the MPGs. Projections on a sectoral basis and by gas, are planned to be included in BTR2 once the draft SETs report is finalised (within a year of the enactment of the Climate Change Act No 22 of 2024).

2.10 References

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3 Climate Change Impacts and Adaptation

3.1 National circumstances, institutional arrangements and legal frameworks

3.1.1 National Circumstances

3.1.1.1 Climate and natural environment

South Africa has a diverse climate due to its location and varied topography. South Africa is situated at the southern tip of the African continent, between the subtropics and the midlatitudes, bordered by the Atlantic Ocean to the west and the Indian Ocean to the east. The country has a coastline that stretches over 3000 kilometres along the Atlantic and Indian Oceans, and which is a significant feature of South Africa's geography, playing a crucial role in its trade, economy, tourism, and cultural heritage. In the north, the climate is typically hot and dry, characterized by savannas and deserts. Moving southward, the climate becomes more temperate, with mild winters and warm summers, particularly in coastal regions. Along the eastern coastline, the climate is influenced by the Indian Ocean, resulting in higher rainfall and more humid conditions. In the western part of the country, the climate is Mediterranean, with hot, dry summers and cool, wet winters.

This diverse climate has resulted in the country having a range of environments and vegetation types, including savannas, grasslands, shrublands, forests, and deserts. Different plant species have adapted to thrive in these specific climatic conditions, leading to a rich biodiversity including many endemic species (Rebelo et al., 2006). South Africa hosts three of the world’s 36 biodiversity hotspots (Skowno, 2018).

Nevertheless, South Africa also faces significant biodiversity and environmental challenges. Human activities such as urbanization, agriculture, and resource extraction have placed significant pressure on the country's natural resources. According to the

South African National Biodiversity Institute (SANBI), over 50% of South Africa's wetlands have been lost or degraded, primarily due to agriculture and urbanization. Additionally, the South African State of Environment Report highlights that between 2000 and 2018, South Africa lost approximately 1.16 million hectares of natural vegetation, with most of the loss attributed to agricultural expansion, urban development, and afforestation (DFFE, 2023). Pollution from industrial activities, mining operations, and urban centers has degraded water quality, soil health, and air quality, threatening both environmental sustainability and public health. Mining activities have left a legacy of pollution and environmental degradation in many areas of the country. The country's extensive mining activities, including coal mining, open-pit mining, and industrial processes, are contributing significantly to local air pollution levels. Mpumalanga is a major coal mining region, and the combustion of coal for energy generation releases pollutants such as sulfur dioxide, nitrogen oxides, and particulate matter into the air. These pollutants can have significant impacts on air quality and human health, particularly in communities located near coal-fired power plants.

3.1.1.2 Demographics

South Africa is a country marked by diversity, with a population comprising various ethnicities, cultures, and languages. According to Statistics South Africa (Stats SA), the 2022 census revealed a population exceeding 60 million, making South Africa one of the most populous countries on the African continent. The age structure leans towards a slightly younger population, with a median age of around 28 years. This high youth ratio presents both opportunities and challenges for the nation's development trajectory, highlighting the importance of investing in education, skills development, and job creation to harness the demographic dividend and unlock the potential of the youth as drivers of economic growth and social progress. However, the country also faces an aging population, with a growing number of individuals exceeding 65 years, leading to a dependency ratio of 48.8.

South Africa faces significant disparities in access to education and healthcare. The public healthcare system is intended to serve most of the population, particularly those who cannot afford private healthcare services. The public health care sector faces numerous challenges, including resource constraints, infrastructure deficiencies and staff shortages (NDoH, 2020). Rural and underserved areas often bear the brunt of these challenges, where limited access to healthcare exacerbates the vulnerability of marginalized communities to the health impacts of climate change. For instance, extreme weather events such as heatwaves, floods, and storms can lead to injuries, waterborne diseases, and vector-borne illnesses, disproportionately affecting populations with inadequate access to healthcare services. Without timely and effective healthcare interventions, these communities may experience higher morbidity and mortality rates during climate-related disasters. Furthermore, chronic health conditions exacerbated by climate change, such as respiratory diseases and malnutrition, pose significant challenges to healthcare systems that are already strained by limited resources and capacity.

South Africa also faces challenges in access and quality of education, with significant gaps in quality and resources between schools serving affluent and disadvantaged communities. Education plays a crucial role in raising awareness, building knowledge, and fostering adaptive capacities among communities and individuals. However, unequal access to quality education limits the ability of vulnerable populations to understand climate risks, adopt sustainable practices, and participate in adaptation efforts. Addressing the social and economic disparities exacerbated by climate change is crucial for building resilience within these communities and ensuring that adaptation measures are inclusive and equitable.

Urbanization is another key demographic feature, with over 67% of the population residing in urban areas (Mthiyane et al., 2022). Gauteng province, encompassing Johannesburg and Pretoria, is the most populous, highlighting the economic pull of major metropolitan centres. South Africa's urban population accounts for most of the country's economic activity, infrastructure development, and social services provision. However, urbanization also poses challenges related to informal settlements, inadequate housing, unemployment, and socio-economic inequalities, underscoring the importance of urban planning, inclusive development strategies, and equitable access to services to ensure sustainable urban growth and improve the quality of life for all residents. Vulnerable communities, particularly those living in informal settlements, are often disproportionately affected by extreme weather events, such as floods, droughts, and heatwaves. These communities often lack the resources and capacity to cope with climate-related shocks and disasters, placing them at greater risk of displacement, food insecurity, and loss of livelihoods.

3.1.1.3 Economic profile

The economy of South Africa is one of the most developed and diversified on the African continent, encompassing a mix of industries such as mining, manufacturing, agriculture, finance and services. The economy is heavily reliant on its abundant natural resources, including minerals, metals, and a diverse range of agricultural products, which serve as significant drivers of growth and development. The country's vast reserves of coal and other minerals have historically powered its industrial sector, making substantial contributions to GDP, foreign exchange earnings, and employment. However, South Africa's dependence on fossil fuels for energy production poses a significant challenge as the country navigates the global transition to greener economies.

Despite its strengths, South Africa's economy struggles with persistent issues such as high unemployment, income inequality, and slow growth with a large portion of the population living below the national poverty line. In South Africa approximately 49.2% of the adult population live below the upper-bound poverty line (UBPL) (StatsSA, 2019). People living in poverty often lack the resources to prepare for and cope with climate shocks like floods, droughts, or extreme weather events. The country's Gini coefficient of 0.67, a measure of income inequality, remains among the highest in the world, highlighting the deep divides between rich and poor. This inequality is often compounded by persistently high levels of unemployment, particularly among the youth and historically disadvantaged communities. Official statistics from Statistics South Africa (StatsSA, 2022) show that the unemployment rate among South Africans aged 16 to 64 who are actively seeking work reached 32.8% in 2023, the highest rate among G20 countries.

As South Africa's socio-economic sectors are intricately linked to the environment, climate change threatens to disrupt these sectors, undermining livelihoods and economic growth. For example, the agricultural sector, a cornerstone of the economy, is increasingly threatened by water scarcity, soil degradation, and pest outbreaks exacerbated by climate change. Increased temperatures, changes in precipitation patterns, and extreme weather events like floods and droughts can disrupt agricultural activities, leading to food insecurity and economic losses. South Africa is already a water-scarce country, due to the combination of an inherently low and variable rainfall, high evaporative demand, and the rapidly rising demand for water for agriculture, industries and urban areas (Rasifudi et al., 2023). Similarly, the energy sector, which relies heavily on coal-fired power plants, is vulnerable to disruptions caused by extreme weather events and the transition to renewable energy sources. Investing in sustainable and climate-resilient economic development pathways is thus essential for ensuring long-term prosperity and reducing carbon emissions.

South Africa's infrastructure is a vital backbone of its economy and society, encompassing a diverse network of roads, railways, ports, airports, energy facilities, water systems, and telecommunications networks. As the most industrialized country in Africa, South Africa's economic activities, trade, and connectivity rely heavily on its infrastructure, which spans vast distances.

Although infrastructure plays a critical role in supporting South Africa's economy and society, it is also highly susceptible to the impacts of climate change. Aging infrastructure, inadequate maintenance, and poor planning exacerbate vulnerabilities to extreme weather events, such as flooding, storm surges, and sea-level rise. Climate change is impacting South Africa's coastline, which is vital for the country's economic activities, through rising sea levels and more frequent storm surges. These hazards could bring increased coastal flooding and erosion that can damage infrastructure, threaten coastal ecosystems, and displace communities living in low-lying areas.

3.1.2 Institutional Arrangements

South Africa's climate change institutional arrangements span from the national to the local levels of government, emphasizing collaboration, research, civic society and sectoral action to combat climate change. The institutional arrangements and governance for climate change adaptation in South Africa involve a comprehensive and integrated approach, with clear roles and responsibilities for various stakeholders. These institutional arrangements are designed to ensure the effective assessment of climate change impacts, and the systematic and transparent conduct of decision-making, planning, coordination, consultation, participation, monitoring, and reporting. Collaboration between government bodies, research institutions, and civil society, is essential for developing effective institutional arrangements. Hence, collaborative efforts are crucial for building resilience and adapting to the challenges posed by climate change. Figure 3.1 shows the institutional arrangements and governance for climate change adaptation in South Africa.

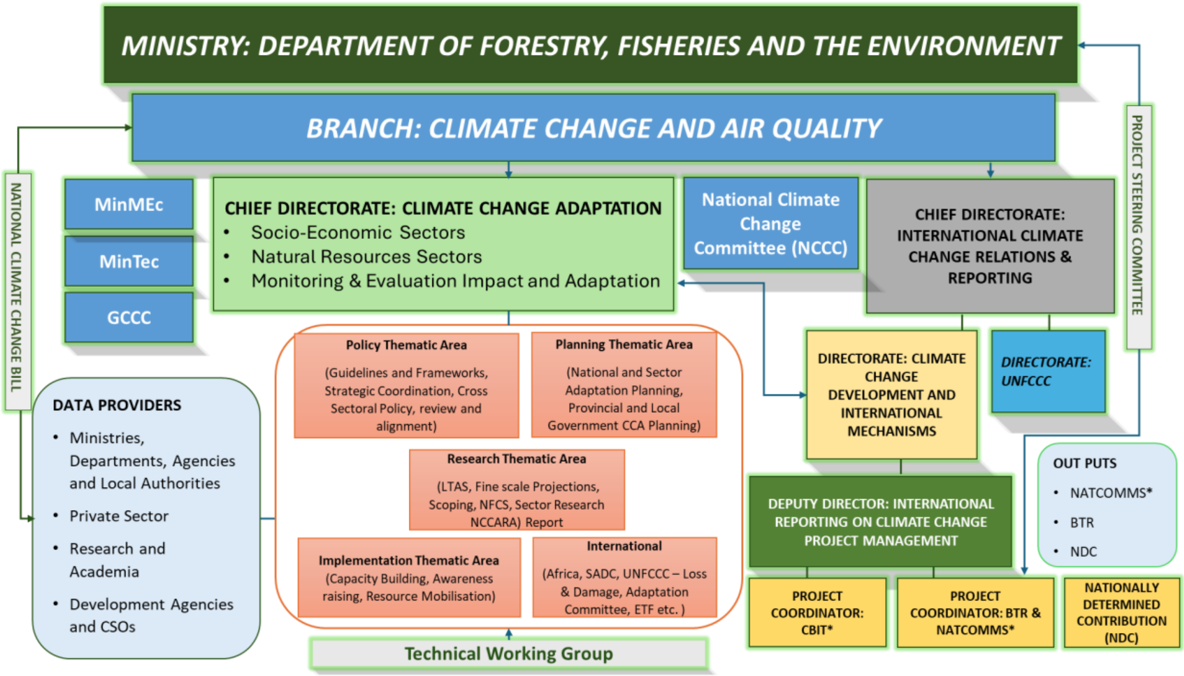

Figure 3.1: Institutional arrangements and governance for climate change adaptation in South Africa

3.1.2.1 Intra-departmental arrangements

The Department of Forestry, Fisheries, and the Environment (DFFE) plays a pivotal role in South Africa's climate change adaptation efforts, providing leadership, policy direction, and support for various adaptation initiatives nationwide (Figure 3.1). Within the DFFE, the Branch: Climate Change and Air Quality (CCAQ) is specifically tasked with promoting, facilitating, informing, monitoring, and reviewing the integration of environmental sustainability, low carbon development, climate resilience, and air quality into South Africa's transition towards sustainable development.

The CCAQ Branch oversees several key functions through its Chief Directorates, which lead and support national, provincial, and local climate change adaptation responses. The Climate Change Adaptation Chief Directorate is responsible for the national policy on adaptation, enforcement of implementation by sectors at provincial and local levels through the three directorates listed below:

- Directorate: Climate Change Monitoring and Evaluation – Impact & Adaptation
- Directorate: Adaptation Natural Resource Sectors
- Directorate: Socio Economic Sectors

The Chief Directorate manages the Monitoring and Evaluation (M&E) of adaptation efforts through the web-based National Climate Change Information System (NCCIS), which consolidates data from various sources for reporting purposes. Analysed data from the NCCRD within NCCIS is then forwarded to the Chief Directorate: International Climate Change Relations and Reporting. This chief directorate oversees reporting to international bodies, including the United Nations Framework Convention on Climate Change (UNFCCC), through National Communications and Biennial Transparency Reports.

3.1.2.2 Inter-departmental institutional arrangements

Other national-level departments and institutions such as the South African National Biodiversity Institute (SANBI), the Department of Agriculture, Land Reform, and Rural Development (DALRRD), and the Department of Water and Sanitation (DWS) support DFFE in its climate change agenda through collaborative efforts, integrated policies, and coordinated actions. The South African Weather Service (SAWS) plays a crucial role within DFFE by providing essential meteorological and climatological services that support the Department's mandate in addressing climate change, environmental management, and disaster risk reduction. SAWS operates as a public entity under the auspices of the DFFE, ensuring that its activities are aligned with national environmental and climate objectives.

The different national-level departments and institutions collaborate on data collection, analysis, and sharing, as well as providing comprehensive and accurate information for informed decision-making and effective climate action. They also engage in collaborative research initiatives to develop innovative solutions for climate challenges, leveraging expertise and resources from multiple sectors.

3.1.2.3 Advisory Bodies

The National Climate Change Committee (NCCC) coordinates and monitors the implementation of climate change policies across sectors. It includes representatives from government departments, civil society, and the private sector.

3.1.2.4 Assessment of Impacts

Sectoral departments conduct assessments of climate change impacts relevant to their domain. DFFE also plays a role in coordinating these assessments and ensuring a consistent approach. Various research institutions and universities contribute to climate change impact assessments through research and data collection.

3.1.2.5 Decision-Making, Planning, and Coordination

The Cabinet, informed by DFFE and other relevant departments, makes final decisions on national climate change strategies and policies. Sectoral departments develop their own climate change plans within the framework of national strategies. The NCCC plays a crucial role in coordinating climate change action across sectors and ensuring coherence in policies and plans.

3.1.2.6 Consultation and Participation

Stakeholder consultations are an essential part of the policy development process. DFFE and sectoral departments engage with civil society, the private sector, and communities to gather input and ensure that their needs are considered. Public participation platforms exist to allow citizens to voice their concerns and participate in decision making related to climate change.

3.1.3 Adaptation policy landscape

South Africa has made significant progress towards becoming a low carbon and climate resilient society. As a signatory of numerous global climate change responses including the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, and the Paris Agreement, the country continues to strengthen its efforts in achieving and stabilizing greenhouse gas (GHG) concentrations in the atmosphere and adapting to the impacts of climate change. South Africa has also developed overarching policies and frameworks to support climate change responses. Its climate change response actions are guided by Section 24 of the Constitution of the Republic of South Africa (RSA, 1996), the National Development Plan 2030 (NDP 2030) (NPC, 2012), the National Climate Change Response Strategy (NCCRS) (2004), and National Climate Change Response Policy (NCCRP) (DEA, 2011) which builds on the NCCRS. NDP 2030 defines the country's development pathway and is closely aligned with the Sustainable Development Goals (SDGs). The NCCRP provides a clear framework for the mainstreaming of climate-resilient development; all government sectors must ensure that all policies, strategies, legislation, regulations, and plans are in alignment with the NCCRP (DEA, 2011).

Key developments since the NCCRP have been the submission of the country's first Nationally Determined Contributions (NDC) in 2015 (RSA, 2015), which was updated in 2021, and the National Climate Change Adaptation Strategy (NCCAS), approved by national government in 2020 (DEA, 2019). The NDC is the cornerstone of South Africa's climate change response and covers adaptation and mitigation, as well as finance and investment requirements, and was based on equity (RSA 2015). SA's updated NDC (submitted in September 2021) included the country's first adaptation communication and a section on international support requirements (RSA, 2021). South Africa's first NDC provided a channel to communicate the country's high-level vision and objectives on adaptation to the international community, while the NCCAS communicates the country's adaptation priorities.

The National Climate Change Adaptation Strategy (NCCAS) is the country's National Adaptation Plan (NAP). It outlines a vision for adapting to and building climate resilience against climate change, enabling the country to fulfill its commitment under the Paris Agreement. The NCCAS is aligned with South Africa's policy and laws, incorporating relevant principles and commitments from international agreements. It supports the NDP's vision of creating a low-carbon, climate resilient economy and a just society.

Recognising the need to strengthen the climate change mandate, South Africa developed a Climate Change Bill which is the latest instrument to ensure enhanced (scaled-up) climate action in South Africa. The Bill was tabled in Parliament in February 2022 and went through various public participation and law-making processes to become South Africa's Climate Change Act. The Climate Change Bill was signed into law by the President of South Africa on 23 July 2024. However, it should be noted that during the BTR reporting period covered in this chapter, the Climate Change Act is still referred to as the Climate Change Bill. The Climate Change Act, as endorsed by the President, mobilizes South African society towards a climate-resilient and low-carbon economy. This legislation outlines the institutional structures for coordinated climate action and cooperative governance across different ministries and tiers of government. It achieves this by defining roles and responsibilities and granting authority to different government departments and levels to take appropriate action. The Climate Change Act provides clear frameworks for mitigation, adaptation, as well as a mechanism to support and finance the country's climate change response. In terms of mitigation, the Climate Change Act provides for a just transition away from our current carbon-intensive energy system and towards a decarbonized economy and society, while meeting our critical development challenges. From an adaptation perspective, the Act provides for the establishment of national adaptation objectives, the development of climate scenarios to assess vulnerabilities, and a National Adaptation Strategy and Plan to manage adaptation in a clear and coordinated manner. The Act also states that national adaptation objectives will be used to guide the country's adaptation response and that a national adaptation strategy must be developed and reviewed every 5 years. In terms of climate finance, the Act provides the mechanisms to support and finance the climate change response, providing guidance and a governance framework to promote planning and implementation by national, provincial and local government.

The climate policy landscape and how this has evolved over time in terms of national climate polices is shown in Figure 3.2.

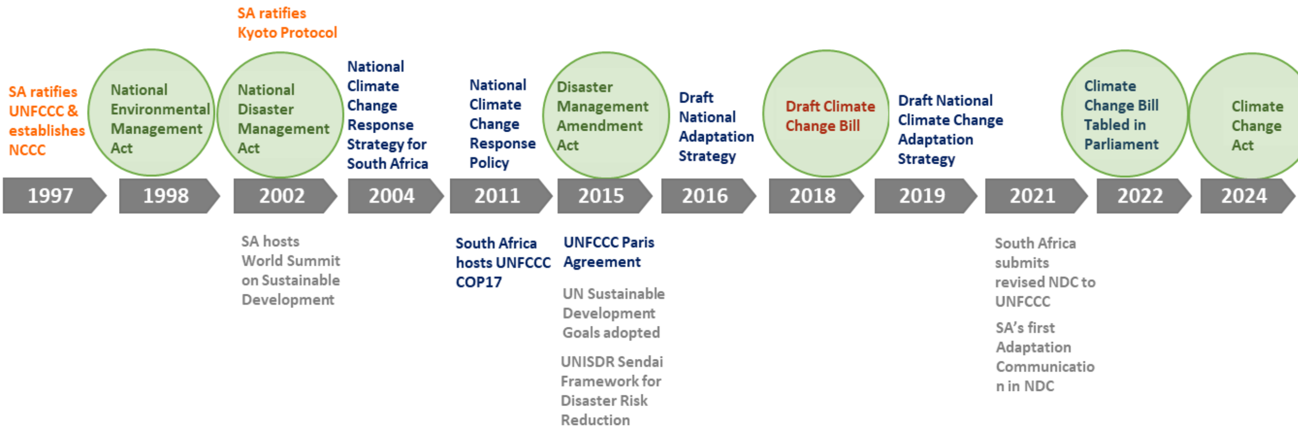

Figure 3.2. South Africa's policy environment and responses to international processes of relevance to adaptation in South Africa from 1997 to 2024

3.2 Impacts, risks and vulnerabilities

3.2.1 Overview of the climate of South Africa

South Africa possesses various climatic regions, ranging from the steppe hot summer rainfall region (marked 1 in Figure 3.3), the Sub-tropical climatic region (marked 2 in Figure 3.3), the temperate hot summer region (marked 3 in Figure 3.3), the arid desert and semi-desert climate in the western parts of the country (marked 4 in Figure 3.3), and the Mediterranean climate in the south-western Cape (marked 5 in Figure 3.3; Taljaard, 1994; Beck et al., 2018). These regions have also been classified according to the Köppen-Geiger historic climatic classification (Beck et al., 2018). The steppe hot summer rainfall region is characterized by semi-arid and hot conditions with rainfall seasons observed between November and March. The Mediterranean climatic region is experiencing mild, rainy winters and hot, dry summers. Mid-latitude storms bring heavy to extreme precipitation to the Mediterranean climatic region in winter (Favre, et al., 2013). Subtropical lows, such as CoLs, are known for causing severe weather and significant precipitation events (Engelbrecht et al., 2012; Favre, et al., 2013; Du Plessis and Schloms, 2017). The Temperate climatic region is characterized by dry, cold winters due to subsiding air from strong high-pressure circulations. These high-pressure systems move southward in summer, resulting in favourable conditions for wet summers in Temperate regions (Mahlalela et al., 2019). The Sub-tropical climatic region is regarded as an all-year-rainfall region, with hot, humid summers and mild, moist winters. Here, summer extreme precipitation events are typically caused by tropical storms in the east or by mid and upper-level troughs elsewhere. The desert and semi-desert climatic regions are characterized by warm-to-hot and dry conditions (Taljaard, 1994).

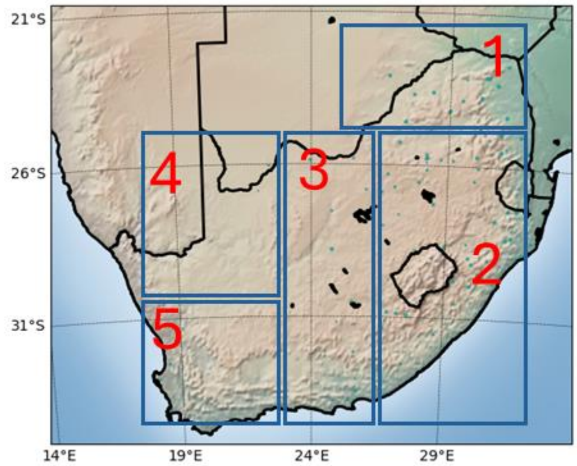

Figure 3.3: The climatic regions of South Africa, based on the Köppen-Geiger historic climatic regions of South Africa (Beck et al., 2018): (1) the summer rainfall area, (2) the all-year-rainfall area, (3) the temperate semi-arid region, (4) hot, desert region and (5) mediterranean, winter rainfall region.

Due to its geographical location, South Africa is influenced by tropical and temperate weather systems. The circulation patterns include subtropical anticyclones, easterly lows, subtropical lows/troughs, westerly waves, ridging anticyclones, west-coast troughs, thunderstorms, and tropical cyclones (Preston-Whyte and Tyson, 2000). Furthermore, the country is flanked by the Atlantic Ocean, associated with the cold Benguela current, on the west, and the Indian Ocean, which is associated with the warm Agulhas current, on the east. Most of the country's rainfall comes from moisture transported by the Agulhas current from the Indian Ocean (Taljaard, 1994; Preston-Whyte and Tyson, 2000). Additionally, the weather of South Africa is greatly influenced by the movement of a high-pressure belt circling the globe between 25º and 30º south (latitude) during winter, and the presence of low-pressure systems in summer (Taljaard, 1994; Preston-Whyte and Tyson, 2000).

There is indisputable scientific evidence confirming that there is global warming, and the climate is changing. South Africa is among the countries that are suffering drastically as a result (USAID, 2015; IPCC, 2018; Scholes and Engelbrecht, 2021). The World bank gives a summary of natural hazards that were observed between 1980 and 2020, of which storms and flooding events take the lead in frequency (The World bank Group, 2021). In terms of weather-related disasters, these are followed by wildfires and droughts. Also, statistics from the South African Weather Service (SAWS) show that both drought years and wet years have become more frequent in some provinces, including the North-West, the Northern Cape, and the Free-State (SAWS, 2023). Contrarily, the Eastern Cape has been experiencing more wet years, while Mpumalanga, Gauteng, KwaZulu-Natal and Limpopo provinces have mainly experienced dry years since the beginning of the 21st century.

South Africa is at the forefront of the global climate change crisis. The evidence is seen in temperature rise, changes in precipitation patterns, increased frequency and intensity of extreme weather events, amongst others. There is a general warming trend, with significant increases in observed temperature, particularly in higher latitude regions. Further evidence shows that South Africa has been warming at 1.5-times the global warming rate (Wolski, P. 2019).

Observed climate trends over Southern Africa reflect that the regions are warming at a that is least twice the global warming rate with parts of South Africa being imparted the alarming warming rate 1931-2015 (DEA, 2018). The National Communication has further shown that during the period 1921 -2015 parts of the country has experienced a higher frequency of hot days than cold nights. Moreover, there has been an increase in rainfall amounts and frequency in the southern interior regions extending into parts of the Northern Cape, Northwest, Free State, and Gauteng, as well as well as significant decreases in annual rainfall totals over Limpopo. The associated extreme weather phenomena include recent heavy rainfall and flooding events such as (FloodList, 2024).

3.2.2 Extreme weather events impacts and their climate change attribution

Despite significant scientific efforts in developing climate model-based evidence over the South Africa region, attribution of change in the characteristic extreme climate events, especially those that are already established as characteristic of South Africa climate variability, is still at its infancy stage. While the signal of climate change is largely based on long term(derived from above 20years climate variables time series) term shifts, experienced impacts of climate change could manifest on weather time scales. Profiled in this section are extreme weather events whose characteristics could have been potentially modified by the rapid warming in global temperatures and therefore merit further attribution research attention. An examples of catastrophic recent extreme weather include:

- Widespread heavy rainfall event (recorded on 23 to 26 September 2023), associated with a severe cut-off-low (COL) pressure systems on ,over the Western and Eastern Cape resulted in severe infrastructure damage, loss of three lives and 21 injuries. The loss of life was reported to have resulted from indirect climate driven factors such as weather condition associated road accident, major road damage and closures, power failure and challenges in the evacuation of about 2000 families during a severe cut-off-low (COL) on 23 to 26 September 2023. Another COL associated with strong winds and heavy rain was observed over parts of KwaZulu-Natal on 27 June 2023. The event was associated with a water sprout, and it resulted in major infrastructure and property damage, loss of at least seven lives, beach pollution and loss of agriculture.
- A COL that wreaked havoc, resulted in the loss of over 400 lives was reported on 9 – 12 April 2022. The amount of damage caused by the storm was estimated at R7 billion. A large number of jobs, ports, manufacturing plants, agriculture, the water and energy sectors, travel and tourism sector, and a large number of small-to-medium enterprises were greatly affected.
- Flooding events that occurred one after another within a short period of time, leaving residents in great difficulty. This occurred on 8 February and 17-19

February over parts of the Eastern Cape. The former resulted from a COL while the latter resulted from an upper-air-trough. The former was associated with severe damage to infrastructure and had major impacts on the tourism industry as camps at the Kruger National parts were closed. The latter was associated with dam overflows, two fatalities and five missing persons, severe damage to infrastructure, etc.

- A flash flood that resulted in nine fatalities and eight missing persons was reported over Johannesburg on 3 December 2022. The event resulted from a surface trough over the central parts of the country, which further resulted in favourable conditions for the formation of a severe thunderstorm.

According to the annual state of climate report of South Africa, 2019 was the hottest year on record since 1951, followed by 2016 and 2015 (SAWS, 2023). As a result, the Western Cape faced a severe drought that significantly impacted both agricultural and urban areas (Johnston et al., 2024). By the summer of 2018, the situation peaked, with "Day Zero", i.e. the day the water supply in Cape Town was expected to completely run out, becoming a highly possible. This would have made Cape Town the first major city in the world to run out of water. Moreover, the top five hottest years were observed during the 21st century.

3.2.3 Historical climate trends and projected climate change over South Africa

3.2.3.1 Temperature and precipitation trends in South Africa

Climate models' simulation of historic and future climate is critical for investigating historic trends and possible future patterns of shifts in the climate and its associated extremes under both understanding climate variability and change. The climate model evidence of unprecedented shifts in the climate of the region and that of the associated key drivers are critical in informing the understanding of vulnerability and hence risk induced by climate variability and change. The outcome of climate modelling efforts is also critical for informing policy and providing guidance to sectors that may be affected by climate change. This includes drought monitoring, leading to significant precipitation deficits, evidence of changes in fire weather, flooding, heatwaves and other compounding extreme precipitation and temperature events. A substantial body of literature has been established reflecting the severity, frequency, duration, and exceedance of critical thresholds to support various national reporting obligations such as the Nationally Determined Contributions (NDC) Adaptation component technical report (CSIR, 2021) and National Communications (DEA, 2018). The NDC report highlights the different aspects of climate change and associated impacts on various sectors (agriculture, forestry and fisheries, biodiversity, health, human settlement and water sector), amongst others.

This section summarizes South Africa's state of climate since 1960 and climate projections up to the end of the 21st century. The change in climate and climatology of extreme climate events is calculated relative to the 1961-1990 reference period and during the 1.5, 2.0 and 3.0°C warming Levels. The climate change signal is analysed using eight bias-adjusted Coupled Model Intercomparison Project Phase 6 (CMIP6) models that also contributed to the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP; Lange, et al., 2021). The selection of CMIP6 models has been shown to have acceptable performance in terms of capturing various atmospheric phenomena, specifically, those that had high performance in capturing El Niño–Southern Oscillation (ENSO) as it is critical for South African weather and climate (Fasullo, 2020; Steyn and Matladi, 2023). As part of the ISIMIP project, the models (CESM2, NorESM2-MM, GFDL-ESM4, EC-Earth3, MRI-ESM2-0, ACCESS-CM2, CNRM-ESM2-1 and MPI-ESM1-2-LR; Lange, et al., 2021) were both bias-corrected and downscaled to 0.5 x 0.5 º resolution. The 0.5 x 0.5 º resolution Climatic Research Unit (CRU) data, which comprises multiple variables of mean monthly climatology for global land areas, was used to validate these models (Harris et al., 2020).

Two categories of climate extremes are analysed, namely, temperature extremes and rainfall extremes. Temperature extremes focus on investigating anomalies of the maximum daytime temperature time series (txx) and consecutive dry days (CDD), which speak to temperature extremes and dry spell frequency, respectively. Rainfall extremes refer to precipitation that are quantified through the r20mm index which quantifies the frequency of occurrence of rainfall above 20mm and the count of consecutive wet days (CWD). Further, the analysis is conducted for the three future global warming levels (GWLs), i.e., 1.5, 2.0, and 3.0 °C, across four Shared Socioeconomic Pathways (SSPs), i.e., ssp1-2.6, ssp2-4.5, ssp3.70 and ssp5-8.5. Additionally, the analysis was conducted for five regions in South Africa (Figure 3.3) selected in line with the Köppen-Geiger historic climatic regions of South Africa (Beck et al., 2018).

3.2.3.2 Climatology and projections of extreme temperature and rainfall events

Figure 3.4 depicts precipitation anomalies calculated relative to the 1961 – 1990 baseline as well as anomalies of observed precipitation calculated relative to the 1960 – 2022. The anomalies are spatially averaged over the five key climatic regions over South Africa.

Figure 3.4 depicts that, for precipitation, the bias-adjusted climate variability for ISIMIP models (the green historical line) is within the range of variability for the CRU observations (pink envelopes) for all South African climatic regions. However, there are instances when the models do not produce the magnitude of precipitation extremes that falls within the variability of the CRU observations (the green historical line that goes outside the pink envelope in all the regions). This is most pronounced over temperate region 3, the desert and semi-desert region 4 and the Mediterranean region 5 between the 80’s and 90’s. Nevertheless, the frequency of these extreme events well represented by the models. As a result, there is confidence in using the models to calculate rainfall extremes for future climate.

Further, the medians of models from the various SSPs are leaning towards a general decline in precipitation for future climate. This declining trend is most prominent over the Mediterranean region 5, followed by the desert and semi-desert region 4 and the temperate region 3. Less decline is projected for the semi-arid steppe region 1. The Subtropical region 2, which is dominated by high-lying areas, shows the slightest decline in precipitation. This is also the region which manifest a high level of uncertainty with regards to rainfall projections, which may result from some models over-estimating precipitation while other under-estimate it, leading to the 50th percentiles of the models showing little departure from the historical mean. This uncertainty may also result from the fact that course-resolution models are known to have difficulty in resolving precipitation that is due to convection in such areas (Ban et al., 2014). Also, the precipitation decline over the regions generally becomes steeper beyond 2050.

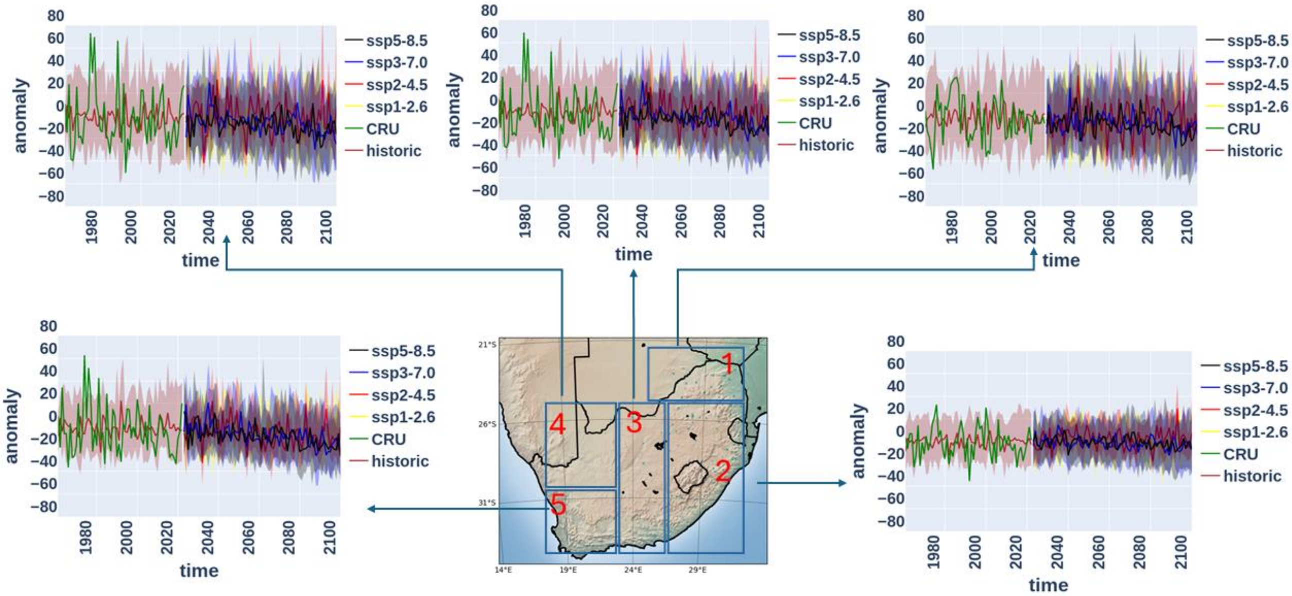

Figure 3.4: Total annual precipitation anomaly (% change) time series for the climatic zones in South Africa based on historic (brown), CRU observations (green), ssp1-2.6 (yellow), ssp2-4.5 (red), ssp3.70 (blue) and ssp5-8.5 (black). The shadings show the 10th and 90th percentiles as a measure of inter-model distribution. The anomalies are calculated relative to the 1961-1900 baseline.

A time series of historical and projected temperature anomalies relative to 1960 – 2022 baseline period is depicted in Figure 3.5. The analysis of spatially-averaged anomalies is shown for five climatic regions of South Africa. The CRU observations and model outputs reflect a warming trend during the historic period relative to a climatological average. The warming signal reflects a plausible consistent increase in temperatures which gets amplified non-linearly going into the future. The warming is in line with the observed global warming trend (IPCC, 2022). The model confidence in the warming signal over South Africa is high (i.e., all models agree on the sign of change). The models reflect that the projected warming rate will likely be highest under the future low mitigation (SSP5.8-5). The model uncertainty in the projected levels of warming for the five respective regions in South Africa gets more pronounced towards the end of the 21st century. However, there is congruence in the historic and projected warming trends among the models.

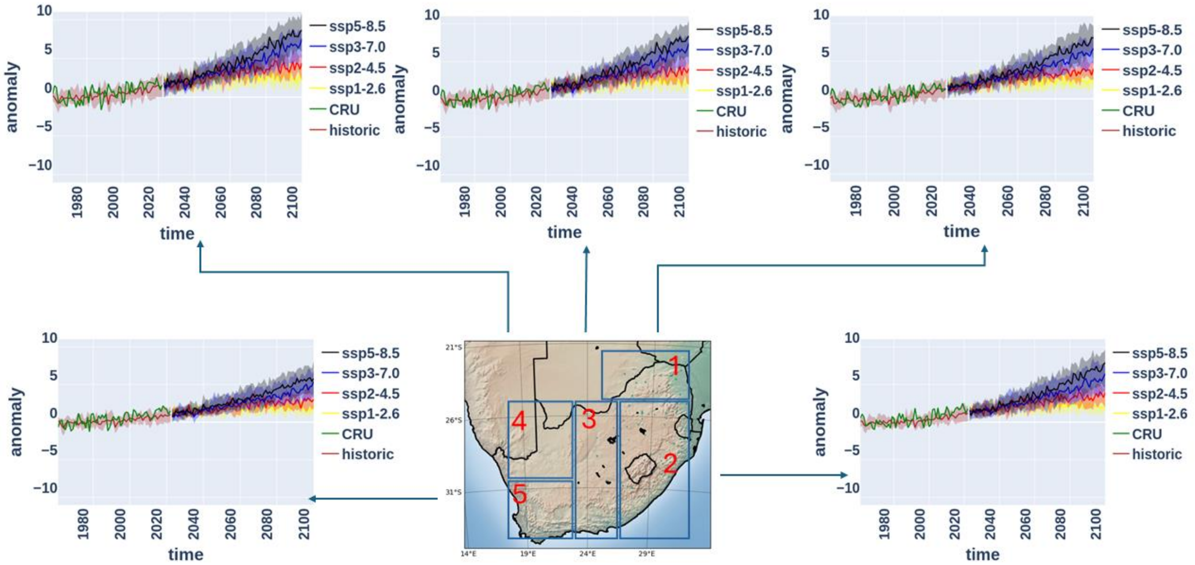

Figure 3.5: Mean annual maximum temperature (°C) anomaly time-series for the climatic zones in South Africa based on historic (brown), CRU observations (green), ssp1-2.6 (yellow), ssp2-4.5 (red), ssp3.70 (blue) and ssp5-8.5 (black). The shadings show the 10th and 90th percentiles as a measure of inter-model variability. The anomalies are from a 1961-1900 baseline.

3.2.3.3 Historic Climate extremes

To get a sense of the current and projected exposure of various sectors of development to physical climate hazard spatial pattern of extreme climate indices are investigated. This section summarizes the pattern of change in the climate extreme events specifically the maximum of daytime temperatures (txx) and frequency of dry days belonging to dry spells or Consecutive Dry Days (CDD), the count of days belonging to a wet spell, or Consecutive wet days CWD) and the count of extreme rainfall days which is used for events that potentially lead to floods.

3.2.3.3.1 Heat extremes

The top panel/row of Figure 3.6 Shows the spatial pattern of maximum temperature over South Africa during the baseline periods. While the average temperature over South Africa reflects a north-to-southwest gradient, the figure reflects that extreme temperature-ranging thresholds of about 36 – 42 °C have been registered for most parts of the country. The similarities in the 10th, 50th, and 90th percentile maps further confirm the narrow model ensemble distribution as reflected on the average temperature time series above which is indicative of model agreement.

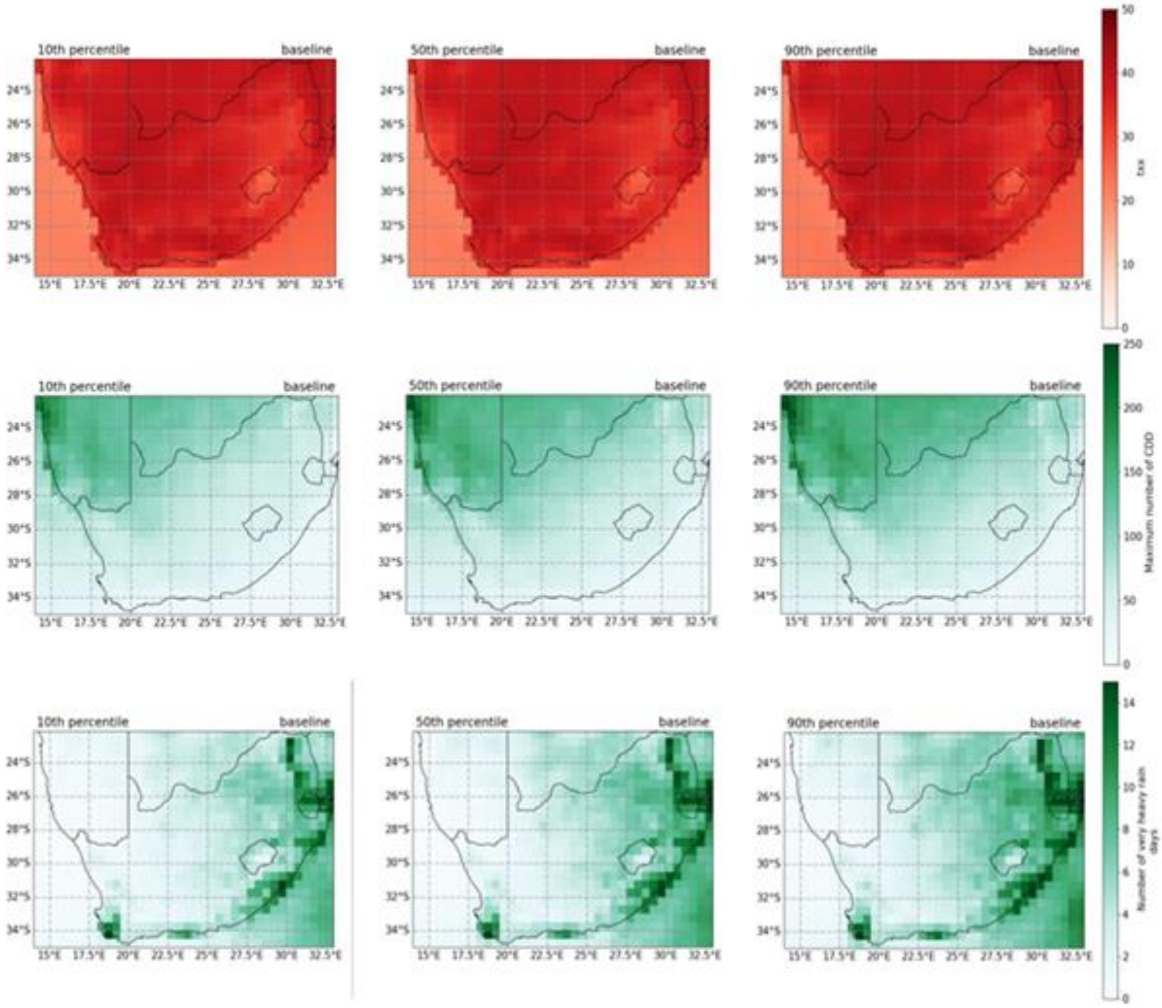

Figure 3.6: Depiction of the historic climate extreme indices, mean annual txx (°C; top row), cdd expressed in in days (middle row), and r20mm reflected in days (bottom row) averaged over the baseline period of 1961-1900. The 10th, 50th, and 90th ensemble percentiles are calculated over the eight models under the ssp3-7.0 scenario.

3.2.3.3.2 Drought

Figure 3.6 (second row) reflects the CDD index during the baseline period. The occurrence of dry spells is higher over parts of the western, central, and eastern interior. As per the 2023 annual State of the Climate report from the South African Weather Service (SAWS, 2023), drought years have become more frequent in provinces such as the North-West, the Northern Cape, and the Free State.

3.2.3.3.3 Floods

According to the WMO (WMO, 2024), changing rainfall and weather patterns are among the most severe impacts of climate change. The implications of extreme rainfall and flooding for South Africa have been evident in the disruption of the hydrological cycles, which impacted river flows, dam levels, and groundwater recharge. The bottom row of Figure 3.6 shows that the number of heavy rainfall days is highest over the southwestern tip of the country, parts of the Garden Route, the east coast, and the north-eastern interior. Heavy rainfall days frequency further decreases from the east to the west of the country. This agrees with the study by McBride et al. (2022), which found the same outcome from a study conducted over the period of 1921 to 2020. Furthermore, the 2023 annual State of the Climate report from the South African Weather Service shows that the Eastern Cape has been experiencing more wet years (SAWS, 2023).

3.2.4 Climate projections

3.2.4.1 Temperature extremes: heat and drought

The 2015 Paris Agreement aims to limit global warming to well-below 2°C, preferably below 1.5°C, above pre-industrial levels (Falkner, 2016; IPCC, 2022). Figure 3.7 reflects the likely changes in the long-term average of the maximum daytime temperatures (txx) and the consecutive dry days (cdd) relative to the 1961-1900 based line. The anomalies are calculated under the scenario SSP3-7.0, during the respective three global warming temperature scenarios or warming, namely 1.5 ºC, 2 ºC, and 3 ºC. These are presented in the form of box plots. These box plots are a graphical representation of the distribution txx and cdd data over the regions of interest and depict key characteristics like the central tendency (median), spread, and presence of outliers (unusually high or low values compared to the majority of the data, which are often outside the expected range of values).

From Figure 3.7, the following is evident:

- For all the climatic regions, the ensemble median average daytime temperatures increase with the increasing global warming levels, indicating that the local extreme daytime temperatures in South Africa are warming with the general warming in global temperatures. Moreover, the interquartile range also increases with global warming levels, for all the climatic regions, except at 2 ºC for region 4. The spread of the interquartile range is indicative of both model uncertainty and spatial heterogeneity in the magnitude of temperature with an increase in the warming levels.
- The central tendency of dry spells, represented by the typical length of consecutive dry days (median), is the highest at 2 ºC global warming level for the climatic regions of South Africa. This is indicative that there will be benefit in keeping global temperatures at 2.0°C for South Africa. This can be realized should the global action and ambition reach the levels at which shifts in global warming levels are kept below 2.0°C relative to the pre-industrial period (1850 -1900). Moreover, the increase in interquartile range is noticeable for region 5. This suggests an increase in the number of days belonging to dry spells for the region at higher global warming levels relative to the pre-industrial reference period. Furthermore, the length of the interquartile range on box-and-whisker plots as well as the outliers are reflective of spatial heterogeneity of change as well as the model uncertainty in representing both precipitation and temperature over the respective regions.

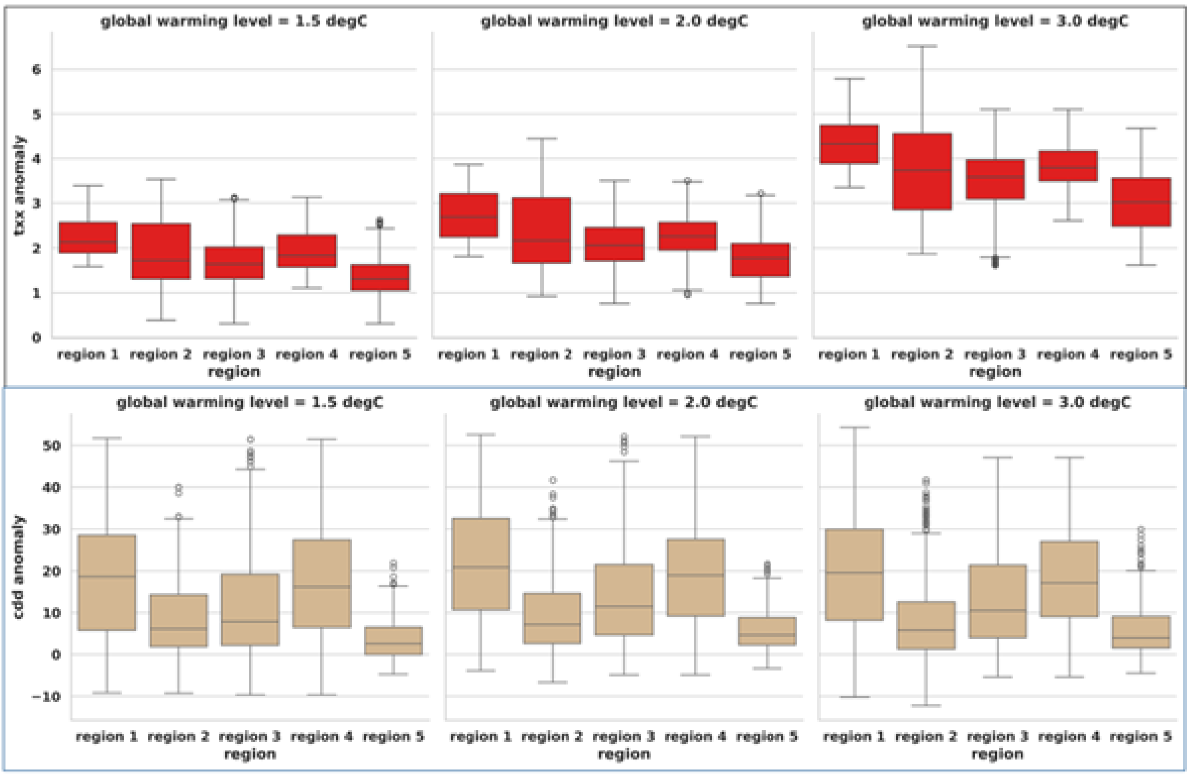

Figure 3.7: Boxplots of mean annual txx (top), expressed in °C, and cdd, expressed in days, (bottom) indices anomalies showing the spatial variability of the five climatic zones of South Africa under ssp3-7.0 for three global warming levels. The anomalies are calculated relative to the 1961-1900 baseline.

3.2.4.2 Rainfall extremes: Flooding and wet days anomalies

Figure 3.8 gives an overview of projections for rainfall extremes, i.e. total rainfall anomalies (top row), heavy rainfall anomalies (middle row), and wet spell (bottom row) in relation to the baseline period. Total precipitation indicates a general trend towards an increase in higher global warming levels relative the pre-industrial period. Looking at the r20mm median change, the extreme precipitation, i.e., precipitation thresholds with a potential of leading to flooding events, are projected to remain within their historic frequency during the baseline period for regions 3-5, while declining for regions 1 and 2 for 1.5 and 2.0 °C warmer world (the models suggest a decline in median r20mm index mean annual average values). During the 1.5 and 2.0°C warmer world the median of the mean annual cwd index (which is indicative of wet spell frequency) is projected to follow a pattern like that of r20mm for all regions. During 3.0°C global warming level regions 2 and 5 reflect negative values. This is indicative of possible decline in wet spell frequency. In summary, looking at the interquartile range there is a clear sign of incongruence between the climate change signal reflected by precipitation and extreme climate indices which are derived from precipitation. This type of uncertainty in the climate change evidence calls for analysis of the impact of climate change on the key precipitation drivers. Adaptation efforts could therefore benefit from anticipating a general decline in annual precipitation % accumulation while also not neglecting a possibility that during a 1.5 - 3.0°C warmer climate the occurrence of destructive precipitation events also be likely.

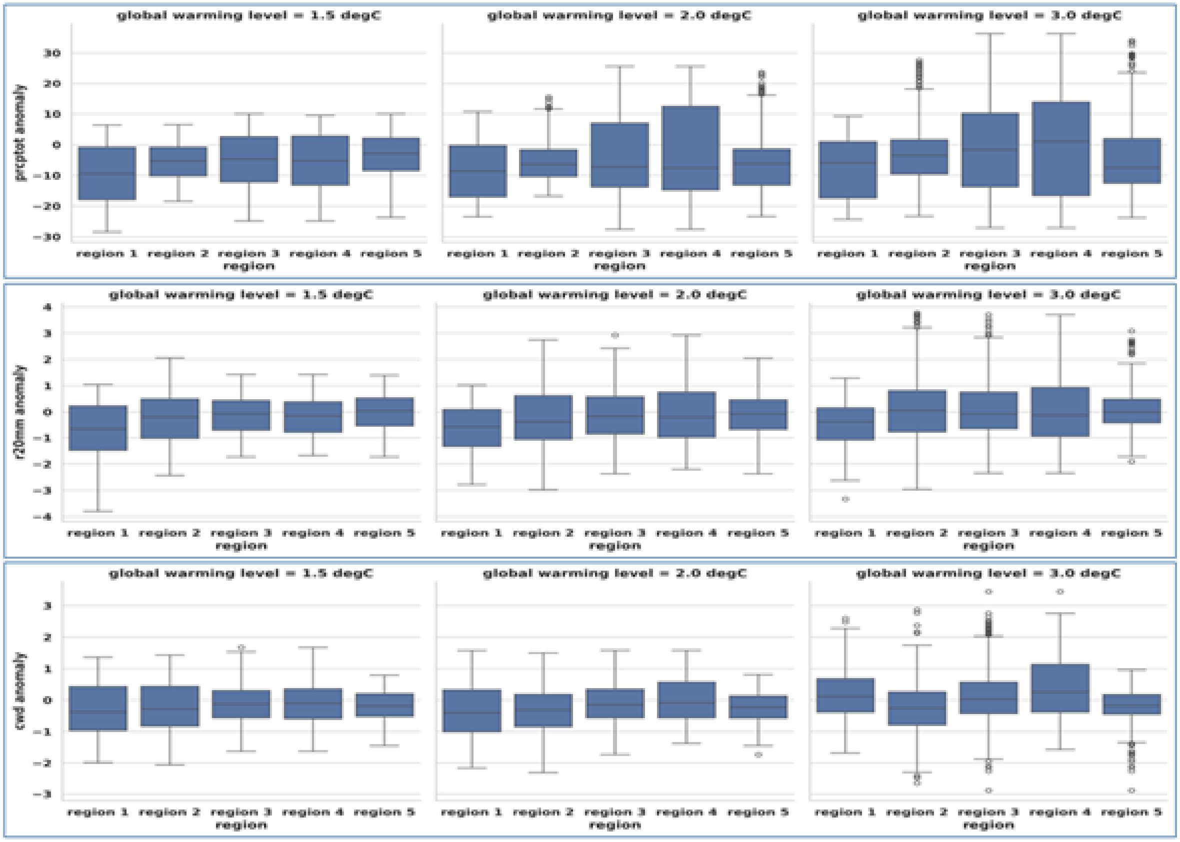

Figure 3.8: Precipitation-based extremes, mean annual prcptot, expressed in % (top), r20mm, expressed in days, (middle), and cwd, expressed in days, (bottom), anomalies boxplots showing the projected changes relative to the baseline during the 1.5, 2.0, and 3.0°C GWLs for five climatic zones of South Africa under SSP3-7.0. The anomalies are calculated relative to the 1961-1900 baseline.

3.2.5 Summary

South Africa faces significant challenges due to climate change, evidenced by rising temperatures, altered precipitation patterns, and more frequent extreme weather events. The country is warming at 1.5 times the global rate, with noticeable impacts on temperature and precipitation extremes.

Results show that, consistent with the IPCC AR6 report, South Africa one of climate change hots-sport. Noticeable impacts include the decline in annual precipitation for some regions despite the signal being uncertain in some regions. The increase in the frequency of dry spells is indicative of a possibility of high drought frequency during the Global Warming Levels. This raises major concerns for resilience of the water, food security and biodiversity among others. Moreover, the medians for rainfall extremes show a general decline in precipitation for the climatic regions except the Mediterranean region 5, where there is spatial and ensemble uncertainty. This is true for 1.5 and 2.0 ˚C GWLs. There is a high likelihood of increases precipitation towards the end of the century, at 3 ˚C GWL. However, increase in the magnitude of maximum temperatures, implying that there may be higher maxima going into the future could also contributed elevated surface water loses. In general, the clear signal of increasing frequency dry spells for the country, with a high level of confidence, spatial and ensemble agreement necessitate drastic resilience measures while South Africa joins the Global Community action and ambition towards keeping global temperatures targets as per the Paris agreement stipulations.

3.2.6 Climate Risks and Vulnerabilities of Key Social and Economic Sectors

The evidence of climate change impacts in South Africa clearly emphasizes the need for the country to build resilience and adaptive capacity to understand and respond to climate change vulnerability and risk. Regular updates of climate risk and vulnerability assessments across key socioeconomic sectors inform the ongoing national risk assessment process and support research and development initiatives. The technical work for updating the NDC presents the most recent vulnerability and risk assessments for key socio-economic sectors, conducted in 2021 at the request of the DFFE. This assessment reviewed and prioritized climate change risks and vulnerabilities for the following sectors: Agriculture and Forestry, Biodiversity and Ecosystems, Health, Urban and Rural Settlements, Water Resources, Coastal Sector, Marine, Mining, Transport and Infrastructure.

The assessments are focused on the national scale and, where possible, provincial-level details are presented to demonstrate the spatial variations.

3.2.6.1 Agriculture and forestry

The agricultural and forestry sector contribute 2-3% to South Africa's Gross Domestic Product (GDP) (DALRRD, 2021). While this contribution may seem relatively small compared to other sectors such as mining, manufacturing, and services, it remains significant due to its critical role in providing employment and supporting rural economies. The commercial agricultural sector also plays a prominent, indirect role in the economy through backward and forward linkages to other sectors.

South Africa's agricultural and forestry products are significant contributors to export earnings. The country exports a variety of agricultural products, such as citrus fruits, wine, maize, wool, and nuts, as well as forestry products like timber and paper. The sector is also an important source of employment, particularly in rural areas where alternative job opportunities may be limited. These sectors provide livelihoods for millions of people involved in farming, forestry, fishing, and related activities.

a. Agriculture

The agricultural sector in South Africa comprises a mix of large-scale commercial farms and smallholder or subsistence farmers. Commercial farming, characterized by large, mechanized farms and agribusinesses, dominates the production of export crops and high-value commodities. It accounts for most of the country's food production, with only 30,000 commercial farmers contributing over 80% of the total food supply (Loeper et al., 2018). Additionally, there are approximately 2 million subsistence farmers and around 200,000 emerging smallholder farmers(Stats SA, 2021). While the productivity of small-scale farming is often viewed as low, the importance of small-scale farming extends beyond mere productivity, as it provides a critical safety net for households, contributing to food security and serving as a crucial source of livelihood for millions of

South Africans. However, the agricultural sector in South Africa faces various challenges, including water scarcity, pests and diseases, market access, and socio-economic inequalities.

One of the primary impacts of climate change on crop production in South Africa is the increasing frequency and severity of extreme weather events, such as droughts, floods, and heat waves (Mangani et al., 2023; Olabanji et al., 2021; Simanjuntak et al.; 2023a, 2022a). These events can have devastating consequences on crop yields, as they can disrupt the delicate balance of temperature, rainfall, and other environmental factors that are crucial for plant growth and development. For instance, a study by Gyamerah and Ikpe (2021) found that the overall revenue from crop production in Africa is projected to decline by up to 90% by 2100 due to climate change, which would be further exacerbated by substantial reduction in the length of cropping seasons and unpredictability of the onset of wet periods(Gyamerah & Ikpe, 2021). Additionally, climate change has also been linked to the emergence and spread of new pests and diseases that can negatively impact crop production. The livestock sector in South Africa has also been significantly impacted by climate change. Increased temperatures, droughts, and changes in precipitation patterns have affected the availability of grazing land and water resources, leading to reduced livestock productivity and increased vulnerability to pests and diseases. Key vulnerabilities and risks for the agricultural sector in South Africa are outlined in Table 3.1.

Table 3.1. Key vulnerabilities and risks for the agricultural sector in South Africa

Sector	Agriculture
Key vulnerabilities	• High dependence on rainfed agriculture. Approximately 80% of South African agriculture relies on rainfall, making it highly susceptible to fluctuations in precipitation patterns (Hartley et al., 2021). • Limited irrigation infrastructure: Uneven distribution of irrigation infrastructure leaves many areas vulnerable to water shortages during dry periods, hindering agricultural production. • Unsustainable management practices: Overuse of synthetic fertilizers and pesticides, overgrazing, use of monocultures, deforestation, and habitat destruction can reduce biodiversity, which is crucial for ecosystem function and resilience. • Soil erosion and land degradation: Over-tilling, inadequate crop rotations, and the failure to use cover crops can lead to soil erosion, nutrient depletion, loss of soil structure, and decreased fertility, which reduces the soil's ability to hold water, making crops more

Sector	Agriculture
	susceptible to drought and reducing long-term fertility. Research has shown that between 7% and 10% of carbon content in soil is lost during every cultivation cycle in South Africa's main cropping areas. According to Le Roux et al. (2008) the average soil loss in areas under grain crops in SA is 13 ton/hectare/year. This is much higher than the natural soil formation rate and it implies that almost 3 tons of soil is lost per hectare (ha) for every ton of maize produced yearly. • Socio-economic factors: A significant portion of South African agriculture consists of smallholder farmers with limited resources. These farmers are often less equipped to adapt to climate change and absorb financial losses due to crop failures. • Limited access to technology and information: Many farmers, particularly in rural areas, lack access to the latest technologies and information on climate-resilient agricultural practices. This can hinder their ability to adapt effectively.
Prioritized risks and impacts	Decline in crop yield, suitability, and quality: • *Heat stress and heat waves* will have detrimental impacts on crop yield and quality. Studies have shown an increasing likelihood of experiencing temperatures exceeding the maximum threshold for maize production in certain areas in South Africa (Challinor et al., 2016; Mangani et al., 2023; Simanjuntak et al., 2022b). Exposure to high temperatures during the maize reproductive stage will affect pollen viability, fertilization, and grain development, which can significantly reduce maize yield between 80 and 90% (Simanjuntak et al., 2023b). In fruit crops it causes fruit sunburn, inadequate pollination, delayed ripening, reduced color development, poor fruit quality and fruit set as well as low fruit yield. Research has shown that apple production in the Ceres area of South Africa will be compromised through a decline in the accumulated PCUs of 2–5% by the 2020s, 7–17% by the 2050s, and 20–34% towards the end of the 20th century. This will have serious economic consequences for farmers and employment in the region. • *Drought:* Multiple droughts in the past decade over Southern Africa have severely impacted maize and staple crop production, leading to significant declines in yield and threatening food security in the region. Recurrent dry spells have reduced water availability, impaired crop growth, and increased vulnerability to pests and diseases. Parts of Southern Africa have been experiencing a severe drought since late 2023, enhanced in part by the ongoing El Niño Southern Oscillation. • Animal health and performance. Heat stress negatively impacts livestock by reducing feed consumption, reproductive and growth rates, and milk production, while also compromising meat quality. The effect of heat stress on milk production in Holstein cattle on pasture in South Africa was modelled by Neser, 2016. It indicates progressive shrinking of currently suitable areas and a geographical shift towards the southern parts of the east coast of South Africa for optimal milk production from Holstein dairy cattle.(Neser, 2016). A study investigating effects of climate change on the distribution of the Bont-legged tick (*A. hebraeum*), the carrier of Heartwater disease in animals, suggests climate change as a reason for the wider spread of Heartwater in South Africa (Leask & Bath, 2020). Heat stress also affects growth and reproduction in animals. For example, it was found that maximum seasonal temperature explains up to 42% of variation in weaning weight in cattle in a dry arid area of South Africa (Jordaan et al., 2021). • Food waste, health, and safety: The secondary impacts of increases in temperature extremes are the increased risk for food spoilage during post-harvest processes as well as reduced marketability and shelf life of food products. This could lead to an increase in food waste as well as having food safety and health risks for humans and livestock. • Distribution, intensity and abundance of pests and diseases. Warmer winters and rising minimum temperatures will drive emerging, new, and more aggressive pests (insects, pathogens, and weeds) affecting crop yield levels and stability. (Mafongoya et al., 2019). Additionally, warmer temperatures will also expand the geographic range and intensity of

Sector	Agriculture
	many pests and diseases in regions that have traditionally experienced low pest risk. This leads to increased costs associated with managing pests and diseases as well as a potential overuse of pesticides, which will necessitate new products. An increase in temperatures could also lead to increased growth of toxigenic fungi in crops (Perrone et al., 2020). The fall armyworm (FAW) is a significant agricultural pest in South Africa and was first detected in early 2017. The extent of its impact in South Africa has been considerable, affecting various crops such as maize, sorghum, wheat, and sugarcane (Mafongoya et al., 2019). Additionally, *Herlicoverpa amigera* (African bollworm) is a problematic insect pest on crops in South Africa, recorded as being dependent on increased temperatures and able to overwinter during the warmer winter season (Phophi et al., 2020). The dramatic increase in South Africa's average winter temperature over the past 40 years has altered the susceptibility of apples to fungal disease, with fungi showing a much faster adaptation rate to changing temperatures than apples (Meitz-Hopkins, 2020) • Loss of market opportunities: Shifts in rainfall and temperature patterns are altering traditional planting and harvesting seasons. In many instances, due to lack of resources, farmers are not able to respond swiftly. • Livelihood loss: Decreased agricultural output can lead to job losses and economic hardship for farmers and communities dependent on agriculture. • Increased food prices: A decrease in domestic food production can lead to a reliance on imported food, making the country vulnerable to fluctuations in global food prices.

b. Forestry

The commercial forestry sector encompasses approximately 1.2 million hectares of land, mostly found in the provinces of Mpumalanga and KwaZulu-Natal, while the Eastern Cape, Western Cape and Limpopo also include some forestry areas. These plantations produce timber for various manufacturing industries, including pulp and paper production, furniture manufacturing, and construction. Plantations are dominated by three main types of trees namely Pinus, Eucalyptus, and Acacia. Pinus or pine trees are the most common species, making up around 49 % of all plantation trees. Wood and paper products are also major export earners for South Africa, generating over R38.4 billion annually. The Forestry and Forest Products sector also employs more than 149,000 people, with most of the forestry workforce living in rural communities (Forestry SA, 2022).

South Africa's forestry industry faces several risks from climate change due to impacts on the supply chain as well as direct bio-physical impacts on forests. These are exacerbated by rising costs of transportation, labour, raw material inputs and energy (Mudombi, 2020). Direct impacts on plantation forests include increased vulnerability to droughts, more intense fires, and heightened susceptibility to both established and emerging pests and pathogens. Climate change has exacerbated the potential for forest fires. The abnormally long and destructive fire season of 2017 attributed to drought conditions across South Africa, causing 29,443 ha of plantation area to be damaged or lost (DFFE, 2018) (Table 3.2). Increased pest outbreaks due to milder winters and warmer temperatures also threaten the health of South Africa's plantation forests. Extreme weather events such as heavy rainfall, drought, and windstorms also increase vulnerability to pests and diseases. Projected increases in temperature and changes in rainfall could result in some areas not being climatically suitable for a specific genotype, with other areas potentially becoming climatically unsuitable for forestry (DEA, 2013a).

Table 3.2. Plantation area damaged by fires and other causes (DFFE, 2018)

Causes of fires	2015/16		2016/17		2017/18		Total area (ha)
	Area (ha)	% affected	Area (ha)	% affected	Area (ha)	% affected	
Natural	747	5	5 232	32	4 681	27	10 660
Accidental	4 652	33	3 356	21	4 049	23	12 057
Arson	3 254	23	2 188	14	4 563	26	10 005
Unknown	5 570	39	5 368	33	3 972	23	14 910
Total	**14 223**	**100**	**16 144**	**100**	**17 265**	**100**	**47 632**

Table 3.3 shows the key vulnerabilities and risks for the forestry sector in South Africa.

Table 3.3. Key vulnerabilities and risks for the forestry sector in South Africa

Sector	Forestry
Key vulnerabilities	• Climate change • Natural disasters • Soil erosion • Invasive species • Land-use conflicts • Competition • Economic recessions • A shortage of skilled workers • Community dependence • Equipment breakdown • Unclear/inappropriate policies/regulations • Corruption
Prioritized risks and impacts	• Increased frequency and intensity of wildfires due to hotter and drier conditions pose a significant risk to commercial plantations in South Africa. Wildfires can cause extensive damage to tree stands, reduce forest cover, and lead to significant economic losses. • Warmer temperatures and changes in precipitation patterns alter the distribution and lifecycle of pests and diseases, potentially leading to more frequent and severe outbreaks. • Changes in temperature and precipitation patterns also affect the growth and distribution of tree species. Some species may become less viable in their current locations due to altered climatic conditions, leading to changes in forest composition and structure. • Increased rainfall intensity and changes in land use patterns can lead to soil degradation and erosion, reducing soil fertility and stability. • The vulnerabilities faced by the forestry sector due to climate change can result in significant economic impacts. Reduced productivity of commercial plantations affects timber supply and associated industries. The costs of managing increased risks, such as wildfires and pest outbreaks, add to the economic burden on the sector. • Many communities in South Africa depend on forests for their livelihoods, including employment in the forestry sector, collection of non-timber forest products, and ecosystem services such as water regulation and soil fertility. Climate-induced changes to forests can threaten these livelihoods, leading to social and economic challenges for rural communities. • Extreme weather events such as storms and heavy rainfall can damage infrastructure related to the forestry sector, including roads, bridges, and processing facilities. This can disrupt operations and supply chains, leading to economic losses and increased costs for maintenance and repairs.

3.2.6.2 Biodiversity and environment

South Africa is a global biodiversity hotspot, boasting exceptional richness and variety in plant and animal life. The country has nine distinct biomes, including savannas, grasslands, deserts, and Mediterranean type shrublands (fynbos). Each biome hosts endemic species unique to its environment. The Fynbos biome, which consists of evergreen, hard-leaved mediterranean type shrubland, comprises over 7,000 plant species not found anywhere else on Earth, showcasing incredible floral and associated animal diversity. The country is also home to iconic mammals including the Big Five (lion, leopard, rhinoceros, elephant, and Cape buffalo). It is also a global hotspot for bird, reptile, and amphibian species. Birdlife flourishes with over 870 species, of which about 60 species are endemic to South Africa. The country's coastal zone supports a variety of ecosystems, including coral reefs, kelp forests, and estuaries. These marine areas are home to diverse fish species, marine mammals, and invertebrates, many of which are important to the country's marine and coastal economy.

This rich biodiversity contributes to vital ecosystem services such as water purification, climate regulation, and soil fertility, and increases resilience against environmental changes and natural disasters. Biodiversity underpins various sectors including agriculture, tourism, and fisheries, all of which are crucial to South Africa's economy.

Table 3.4 shows the key vulnerabilities and risks for the biodiversity sector in South Africa.

Table 3.4. Key vulnerabilities and risks for the biodiversity sector in South Africa

Sector	Biodiversity and Ecosystems
Key vulnerabilities	• Habitat loss, degradation and fragmentation: One of the most significant threats to biodiversity in South Africa is habitat loss, degradation and fragmentation due to unsustainable land and ocean use, urbanisation, agriculture, mining, and infrastructure development. Fragmented and isolated vegetation populations have a reduced ability to adapt to climate change in terms of climate migration (biome shifts). South Africa lost 0.12% of its natural vegetation per year between 1990 and 2018, and 0.24% per year between 2014 and 2018 (Skowno et al., 2021). Additionally, due to these changes, 14% of plants, 17% of mammals and 15% of birds are currently classified as threatened with extinction. Over 70% of the Cape Floral Region has been lost to land use changes. • Rivers and wetlands: Rivers and wetlands are the most threatened ecosystems in South Africa, with 64% and 79% threatened, respectively. Most are critically endangered. This is due to water pollution, invasive species, and changes to their

Sector	Biodiversity and Ecosystems
	hydrological regimes (SANBI, 2018). Increasing temperatures will likely affect the hydrological cycle, exacerbating existing pressures. • Estuaries: According to the South African National Biodiversity Institute (SANBI, 2018), estuaries have the highest proportion of threatened ecosystem types, making them vulnerable to further anthropogenic changes and climate change. Extreme weather events, increased temperature and sea-level rise may lead to further harmful changes in estuaries such as salinity regime shifts, loss of biodiversity due to temperature changes and an increase in pollutants leading to eutrophication, harmful algal blooms and the accumulation of toxic substances. • Invasive alien species: Invasive alien species, particularly trees and freshwater fishes, threaten people, biodiversity and ecosystems in South Africa (Zengeya & Wilson, 2023). Invasive trees such as *Acacia mearnsii* (Black Wattle) threaten indigenous flora, leading to habitat degradation, water loss and biodiversity loss. Alien invasive plants have reportedly covered approximately 7% of the country (Van Wilgen, 2018). • Pollution and contamination: Pollution from industrial, agricultural, and urban sources degrades water and soil quality, posing threats to biodiversity and ecosystem health. It is also a threat to coastal ecosystems. • Water scarcity and drought: Water scarcity and drought exacerbate the vulnerability of ecosystems in South Africa, particularly in arid and semi-arid regions. Competition for water resources between human activities and ecosystems intensifies, leading to habitat degradation and loss of aquatic biodiversity. Reduced rainfall, increased evaporation, and changes in precipitation threaten freshwater availability, affecting wetlands, rivers, and dams. Water is a nexus issue, which means that water scarcity will exacerbate the vulnerability of ecosystems and food and energy production systems.
Prioritized risks and impacts	• Species and biome shift and extinction: Habitat fragmentation prevents organisms from quickly migrating to areas with more favourable climates. The rate of species extinction is alarming, and the severity will depend on the extent of future warming. The fynbos biome, a biodiversity hotspot area of South Africa, could experience extinction rates up to 25%, as the winter rainfall region is expected to shrink in extent. • Increased frequency of extreme weather events: Extreme weather events, such as fires, floods, droughts, and heatwaves can cause immediate and severe damage to ecosystems and species. For example, in fire-prone and fire-dependent ecosystems, such as fynbos, renosterveld, savanna, and grassland vegetation types, fire regimes will likely change to higher fire frequency and intensity. These ecosystems might not have the capacity to recover post-fire, especially if it coincides with droughts in the first year after fire. • Bush encroachment: Increasing levels of atmospheric carbon dioxide are thought to be associated with bush encroachment and increased woody vegetation cover, particularly in South Africa's savanna and grassland ecosystems (O'Connor et al., 2014). Rangeland ecosystems are home to South Africa's iconic game species, and most agricultural activities occur in these ecosystems. Bush encroachment, therefore, threatens the tourism and agricultural sectors. Invasive alien species may also spread more easily in degraded rangelands, increasing the risk. • Economy and livelihoods: Climate change affects agricultural productivity in South Africa, impacting ecosystems and biodiversity. Changes in temperature and precipitation patterns can contribute to crop failures, affecting food availability for humans and wildlife and disrupting ecosystem services provided by agricultural systems.

3.2.6.3 Health Sector

South Africa's health sector comprises a two-tiered system represented by the public sector that caters to most of the population (around 80%) and is funded by government allocations. The private sector serves a smaller portion (around 20%) and relies on private health insurance or out-of-pocket payments. This system leads to significant disparities in access to quality healthcare. Public facilities often face resource constraints, leading to long waiting times and limited access to specialized care. There is also a shortage of healthcare professionals, and the system faces ongoing budget limitations, making it difficult to provide adequate services and keep pace with rising healthcare costs. HIV/AIDS remains a significant public health challenge, although advances in treatment have been made. Tuberculosis and other infectious diseases also pose a significant burden. South Africa is also experiencing a growing prevalence of non-communicable diseases like diabetes, heart disease, and cancer, straining healthcare resources. Climate change poses a significant threat to human health in South Africa, with the potential to exacerbate existing health challenges and introduce new ones. Table 3.5 shows the key vulnerabilities, risks and adaptation strategies for the health sector in South Africa.

Table 3.5. Key vulnerabilities and risks for the health sector in South Africa

Sector	Health Sector
Key vulnerabilitie s	Health sector vulnerabilities may come from many different sources, including; • Cybersecurity threats, which may target health information systems storing personal data • Resource limitations which may result in shortages of medical supplies, insufficient staff and equipment. These limitations restrict timeous and appropriate response to outbreaks or disasters. • Social health determinants such as poverty, social inequality and mental health can increase the risk of health problems; and may also be a barrier to accessing adequate health services. • Air pollution from increased wildfires, among other sources contributes to respiratory diseases, heart diseases and lung cancer • Limited access to safe, clean drinking water, affecting especially rural communities which increase the risk of water-borne diseases • Inadequate sanitation, contaminating water sources and contributing to the spread of infectious diseases

Sector	Health Sector
	• Exposure to toxins and pollutants such as industrial waste and pesticides, used in agriculture. These events and practices can cause new, emerging diseases, or increase the severity of existing diseases, thus putting additional strain on already overburdened health services.
Prioritized risks and impacts	Climate change poses a significant threat to health in South Africa, particularly for vulnerable populations. Some of the priority risks and impacts include: • Climate-related aspects such as rising temperatures and variable precipitation patterns can expand the range and spread of mosquito-borne diseases such as malaria and dengue fever resulting in increased burden of infectious diseases. These diseases may spread into areas where they weren't previously a concern. Higher temperatures have already been linked to cases in Limpopo (Nel and Richards, 2022). The South African National Institute for Communicable Diseases (NICD) monitors weather patterns and malaria transmission rates to predict outbreaks and issue early warnings. (NICD, 2023). The NDoH also released the National Heat-Health Action Guidelines in 2022 (NDoH, 2020a). • More frequent extreme weather events such as floods, droughts and heat waves can disrupt sanitation systems, water supplies and food production. resulting in disease outbreak, injuries and malnutrition, heatstroke, increased cardiovascular diseases. Areas with limited access to clean water are especially at risk of outbreaks of waterborne diseases like cholera and diarrhoea. • Mental health is affected by the stresses of climate change, such as extreme weather events, displacement due to flooding or drought, and food insecurity, increasing conditions such as anxiety, depression, and post-traumatic stress disorder. The South African Department of Health has begun incorporating mental health considerations into climate change adaptation plans and strategies (NDoH, 2020b). • Impacts on food security: Climate change can disrupt agricultural production, leading to food shortages and malnutrition. This can weaken immune systems and make people more susceptible to infectious diseases. • Impacts on healthcare infrastructure: Extreme weather events like floods and storms can damage or destroy healthcare facilities and disrupt essential services such as telecommunications and supply chains, and access routes. The impacts of climate change are already felt disproportionately by those who are already most vulnerable, such as low-income communities, women, the elderly and children.

3.2.6.4 Human Settlements and Infrastructure

Human settlements in South Africa vary from densely populated Metropoles to rural villages, informal and coastal settlements. These settlements face various vulnerabilities to climate change impacts due to their geographical location, socioeconomic conditions, and infrastructure development. The various types of settlements will be discussed according to type of settlement as well as the climate hazards that it faces, its exposure to the hazards as well as the social and economic factors that amplify vulnerability. Settlements can be grouped as follows:

- Urban settlements: These are discussed in terms of urban settlements, peri-urban settlements and mixed (urban/rural) settlements.
- Rural settlements: These include sparsely populated rural areas containing small settlement nodes and denser, spatially distributed rural settlements.
- Coastal settlements: Here climate change vulnerabilities that are specific to the coastal context of affected cities and towns are discussed, such as those driven by sea level rise and storm surges.

a. Urban Areas:

- Infrastructure vulnerability: Urban areas, especially metropolitans such as Johannesburg, Cape Town, and Durban, are vulnerable to climate change due to their dense infrastructure. Floods, heatwaves, and storms can damage critical infrastructure like roads, bridges, and buildings, leading to economic losses and disrupting daily life.
- Heat stress: urban heat islands exacerbate heat stress, particularly during heatwaves, which can pose health risks to vulnerable populations, such as the elderly and the homeless.
- Water stress: Urban water systems may face increased stress due to changing precipitation patterns and increased demand. Droughts and stormwater pollution can lead to water shortages, affecting sanitation and public health.

b. Rural Areas:

- Agricultural impacts: Rural areas are heavily reliant on agriculture are susceptible to changes in precipitation patterns and temperature. Droughts and floods can damage crops, leading to food insecurity and loss of livelihoods.
- Water scarcity: Rural communities often rely on local water sources for drinking and irrigation. Changes in precipitation patterns can lead to water scarcity, affecting both human consumption and agriculture.

- Vulnerability of informal settlements: Informal settlements, common in both urban and rural areas, lack proper infrastructure and services. Informal settlements are particularly vulnerable to flooding, landslides, and other climate-related disasters due to their precarious location and inadequate housing conditions.

c. Coastal Areas:

- Sea-level rise: Coastal settlements face the risk of permanent inundation and erosion due to sea-level rise. This poses a threat to infrastructure, property, and livelihoods, especially in low-lying areas such as Cape Town and Durban.
- Storm surges: Intense storms and storm surges can cause flooding and coastal erosion, damaging homes and infrastructure along the coastline.

Table 3.6 shows the key vulnerabilities and risks for the human settlements sector.

Table 3.6. Key vulnerabilities and risks for the human settlements sector in South Africa

Sector	Human Settlements
Key vulnerabilities	Urbanisation and urban growth: • Urbanisation is progressing in South African towns and cities. According to the GreenBook, between 19 and 24 million more people will reside in South African urban areas by 2050 compared to 2011 (CSIR, 2019). The Institute for Security Studies predicts that South Africa's urbanisation rate will reach 77% by 2043 (ISS, 2023). • The rapid pace of urbanisation often exceeds the capacity of local governments to manage and plan effectively, leading to significant social, economic, and environmental challenges. These challenges can result in high levels of social discontent and political instability. • Key urban challenges include inadequate policy and legislative implementation, poor urban planning, climate change, disaster risks, high inflation, conflict, and food and energy crises (Clos, 2015; Van Niekerk & Le Roux, 2017). • Some of these challenges stem from the colonial and apartheid legacies of cities, while others are perpetuated by current market forces, planning practices, and decades of ineffective urban development planning (Obi, 2016; Van Niekerk & Le Roux, 2017). Spatial and physical vulnerability: • Much of urban growth and transformation is the result of poor development decisions and inadequate planning. Settlements often expand into undesirable areas such as floodplains, coastal flooding zones, and steep hills, exposing communities to climate hazards (IFRC, 2018). • South African settlements face a significant infrastructure deficit, characterised by inadequate water supply and sanitation systems, insufficient energy supply, expensive and unreliable broadband networks, and inadequate transportation networks. Where

Sector	Human Settlements
	infrastructure exists, there is often underinvestment in maintenance, asset replacement, and infrastructure expansion (SADC, SARDC, 2019). • Local governments struggle to meet the demand for water infrastructure and services, leading to severe backlogs, unhealthy living conditions, the spread of diseases, and a lack of dignity for many residents (Van Niekerk et al., 2018). • Climate change is expected to have long-term negative effects on infrastructure. Severe weather events are damaging infrastructure, buildings, roads, and utility systems, reducing their lifespan and creating ripple effects throughout urban systems and the economy (Van Niekerk & Le Roux, 2017; DEA, 2018; IPCC, 2022). Socio-economic vulnerability: • Net rural-to-urban migration is driven by land shortages, poverty, changing rural landscapes, declining agricultural returns, and perceived economic opportunities in urban areas (SADC, 2008; Van Niekerk & Le Roux, 2017; UNECA, 2017; SADC, 2020). • Climate-related impacts such as increasing temperatures, droughts, floods, can lead to displacement from rural areas to urban centres, further increasing urban populations and exacerbating competition for resources and pressure on service delivery (IPCC, 2022). • South Africa attracts a significant number of international migrants and migrant workers, with many moving to towns and cities in search of job opportunities. Approximately 8 million people (3% of the SADC population) are migrants, with South Africa hosting 58.4% of all regional migrants (SADC, 2020). • Urbanisation often occurs without accompanying economic growth and insufficient investment in the built environment, leading to the urbanisation of poverty, where only a few benefit from wealth accumulation (Van Niekerk & Le Roux, 2017). • Inadequate urban planning and infrastructure contribute to increased competition for resources, economic disparities, prejudice, severe inequalities, social fragmentation, and tensions (UN-Habitat, 2019; UN-Habitat, 2022a). • Informal settlements generally offer limited economic opportunities and are unsafe, with dwellings often made from flammable materials and lacking building regulations or land use management and frequently being established in areas unsuitable for settlements, such as flood-prone areas (Van Niekerk & Le Roux, 2017). • Women constitute a large portion of the unemployed or informally employed in urban areas and are disproportionately affected by limited access to safe work environments, resources, technology, and education. • Discrimination against children, the elderly, people with disabilities, and women is increasing, a phenomenon referred to as the "feminization of poverty" (UN-Habitat, 2019). • Youth unemployment and informal sector employment are pervasive, causing significant household distress. • A lack of social safety nets leaves people with few options, inadequate education and skills for formal market access, and insufficient housing, infrastructure, and services (UNECA, 2017; UN-Habitat, 2022a). Environmental vulnerability: • South African cities are characterised by exploitative extraction and unsustainable consumption of natural resources and productive land, pollution, and a heavy dependence on fossil-fuel energy (UN-Habitat, 2019; SADC, 2020).

Sector	Human Settlements
	• Urban expansion is encroaching on natural habitats, and the growing urban population is putting increasing pressure on natural resources (Van Niekerk et al., 2018). • Water, a critical natural resource, is scarce and threatened by urban growth. As urban populations and economies grow, so does the demand for water and the quantity of wastewater. Changing lifestyles often lead to unsustainable consumption patterns, particularly among the affluent. • Studies indicate that 80-90% of wastewater generated in developing country cities is not properly treated before being discharged into surface water bodies (UN Water, 2017).
Prioritized risks and impacts	Urban areas bear substantial climate risks, making resilience and adaptation to climate change one of the most pressing challenges for human settlements. Local governments are at the forefront of addressing climate change impacts, both immediate and long-term (IPCC 2012; Pieterse et al., 2020; IPCC 2022; CSIR 2022): • Increased exposure to extreme weather events: South African settlements face growing exposure to climate hazards, leading to property damage, infrastructure disruption, and threats to human lives and livelihoods. • Water scarcity and increased demand: Changing rainfall patterns and prolonged droughts have caused water scarcity in many parts of South Africa. Urban areas are under pressure to meet the water demands of growing populations, resulting in water stress and necessitating stricter water management practices. • Infrastructure vulnerability: Climate change poses significant risks to urban infrastructure, including buildings, roads, and utility systems. Rising temperatures stress infrastructure, while extreme weather events can cause damage and disrupt essential services. • Coastal vulnerability: Coastal cities and settlements in South Africa are at risk from rising sea levels and coastal erosion, leading to land loss, infrastructure damage, and displacement of coastal communities. • Health risks and disease outbreaks: Climate change can worsen health risks in urban areas. Higher temperatures can cause heat-related illnesses, and changes in rainfall patterns can spread waterborne diseases like cholera. Poor sanitation and inadequate infrastructure amplify these risks. • Food security and agriculture: Climate change impacts agriculture, crucial for many urban areas in southern Africa. Altered rainfall patterns and increased temperatures can reduce agricultural productivity, causing food shortages, price fluctuations, and increased vulnerability for urban populations reliant on agricultural products. • Increased energy demand: Higher temperatures due to climate change increase energy consumption for cooling in urban areas. This puts additional pressure on energy infrastructure and exacerbates greenhouse gas emissions, further contributing to climate change (Van Niekerk & Le Roux 2017; DEA 2018; IPCC 2022).

3.2.6.5 Water sector

South Africa's water resources are unevenly distributed across the country, with most surface water resources located in the eastern and western regions. Much of South

Africa experiences a naturally arid climate with limited rainfall, making water a scarce resource. The Department of Water and Sanitation (DWS) is responsible for managing the country's water resources, developing policies, and regulating water use through permits and licensing. The National Water Act (1998) provides the legal framework for water resources management, emphasizing principles such as equity, sustainability, and efficient water use.

South Africa's surface water resources account for just under 70% of usable water. These surface waters provide water for agriculture (55%), industry (18%), municipal (17%), afforestation (5%), mining (5%) and power generation (2%) activities, with all these sectors being the backbone of the South African economy and development (Rasifudi et al., 2023). Almost 100% of available water resources have been allocated, including provisions for the Ecological Reserve, which should be determined for significant water bodies to inform water use licenses. However, the implementation of the Reserve has generally been poor, thus compromising future water sustainability during mega developmental projects.

Large dams and inter-basin transfer schemes play a crucial role in moving water from surplus areas to water-scarce regions. Major rivers include the Orange River in the west, the Limpopo River in the northeast, the Vaal River in the central region, and the Tugela River in the east. Groundwater supplies around 10% of total supply, and is a vital source, especially in rural areas and during droughts (Rasifudi et al., 2023). However, over-extraction can deplete groundwater reserves.

Table 3.7 depicts the surface water storage of dams per province in South Africa at the end of September 2023.

Table 3.7 Surface water storage of dams per province in South Africa at the end of September 2023 (Rasifudi et al., 2023)

Provinces/ Countries sharing Water Resources with RSA	FSC million m^3	Total	Number of Dams per Province/Country <10%	>=10%<50%	>=50%<100%	>=100%
Kingdom of Eswatini	333.75	1			1	
Eastern Cape	1729.39	46	1	4	28	13
Free State	15656.69	21			20	1
Gauteng	128.08	5			2	3
KwaZulu-Natal	4909.66	19		1	18	
Kingdom of Lesotho	2362.63	2			2	
Limpopo	1480.06	28	1		21	6
Mpumalanga	2538.57	22			20	2
Northern Cape	146.32	5			2	3
North West	867.29	28			21	7
Western Cape - Other Rainfall	271.35	22		3	8	11
Western Cape - Winter Rainfall	1596.80	22			5	17
Western Cape - Total	1868.15	44		3	13	28
Grand Total:	**32020.59**	**221**	**2**	**8**	**148**	**63**

One of the most significant hazards posed by climate change over South Africa and affecting the water sector is the alteration of precipitation patterns, leading to changes in the timing, intensity, and distribution of rainfall across different regions. An increase in the frequency and intensity of extreme rainfall events is predicted over eastern parts of South Africa including the provinces of KwaZulu-Natal, Mpumalanga, and Limpopo. A decline in rainfall is however projected over the western part of South Africa. This phenomenon contributes to increased hydrological variability, including more frequent and severe droughts in some areas and intense rainfall events and floods in others.

Such extremes strain water resources management, affecting water availability for various sectors, including agriculture, industry, and domestic use.

Additionally, rising temperatures associated with climate change exacerbate water stress by increasing evaporation rates and altering the hydrological cycle. Higher temperatures contribute to increased water demand for irrigation, exacerbating competition for limited water resources. This thermal stress also affects ecosystems dependent on specific temperature ranges, leading to shifts in biodiversity and ecosystem services linked to water. Furthermore, elevated temperatures can degrade water quality by promoting algal blooms and microbial contamination, posing risks to human health and ecosystem integrity.

Sea-level rise and coastal erosion, driven by climate change, pose additional risks to South Africa's water sector, particularly in coastal regions. Coastal infrastructure, including water treatment plants, pipelines, and storage facilities, faces the threat of inundation and damage from storm surges and saltwater intrusion. This not only jeopardizes water supply systems but also compromises freshwater resources in coastal aquifers and estuaries. Such impacts disproportionately affect vulnerable communities living in low-lying coastal areas, exacerbating social inequalities and displacement risks.

Water demand will play a critical role in the availability of water resources as well as the management thereof. South Africa is experiencing rapid urbanization, with more people migrating to cities. This population growth translates to a significant increase in water demand for domestic purposes. While urban areas are expected to see the most significant absolute increase in water demand due to population growth, regions already facing water scarcity like the Western Cape will be particularly vulnerable.

Table 3.8 shows the key vulnerabilities and risks for the water sector.

Table 3.8. Key vulnerabilities and risks for the water sector in South Africa

Sector	Water
Key vulnerabilities	• The water sector is sensitive to, and strongly influenced by extreme weather events characterized by frequent and intense droughts and floods as well as extreme rainfall events. • Climate change impacts on water availability are likely to have negative effects on people, ecosystems and the economy. As a result, climate change poses significant additional risks for water security, which in turn has causal effects on the sectors highly reliant on water such as agriculture, electricity generation as well as some industrial and mining activities. • Overpopulation and urbanization: Growing populations and urbanization increase the imbalance between water supply and demand and lead to a higher likelihood of water shortage conditions and contribute to water scarcity. Growing populations also lead to the discharge and runoff of greater quantities of waste and pollutants into the state's streams, rivers, lakes and groundwater.
Prioritized risks and impacts	• Water quality: Warming temperatures will also contribute to exacerbating water pollution and declining water quality, as the risk of algal blooms will increase. The increase in intense rainfall may further contribute to declining water quality due to increased nutrients, sediments and other pollutants which will possibly runoff into rivers, dams, wetlands and soil/plant systems. Increased drought means less water is available to dilute wastewater discharges and irrigation return flows to rivers. Increased frequency of droughts causes water shortages resulting in threatening of household water supplies. • Water availability/supply: Drought conditions and changing rainfall patterns increase stress on internal water resources, aquifers and rivers. • The impact of warming temperatures on surface water include heightened evapotranspiration and evaporation, which result in reduced catchment runoff and increased evaporation from dams. Rainfall is also projected to become more intense, resulting in increased flooding events. Increased periods of drought mean less water is available, which will affect other sectors that rely on water resources for their viability. • Water treatment and storage: The projected increase in localized flooding suggests that increases in the frequency and magnitude of flooding will likely affect most of the country (with the exception of the West Coast and possibly western Limpopo). This suggests that storage, conveyance and treatment structures close to rivers are at greater risk of damages. An increase in flood events may result in deteriorating water quality due to wash off-of sediments, nutrients and other pollutants. This has the potential to impact water treatment costs and efficiency and the usability of water for some applications. Small municipalities and groups responsible for water infrastructure are likely to be most vulnerable. • Human health and wellbeing: More frequent droughts are causing water sources like rivers and springs to dry up or diminish, leading to water scarcity and endangering community health. Increased rainfall intensities, flash floods, and regional flooding are causing water and sanitation systems to become blocked by litter and washed-off debris, resulting in contaminated water and poor sanitation. • Aquatic biodiversity: Water temperature is an important variable in freshwater systems. Warming temperatures will result in habitat degradation and decline in aquatic biodiversity (mortality of temperature-sensitive fish species) due to reduced oxygen concentrations in aquatic environments • Stormwater infrastructure: Risk of damage and failure of infrastructure due to high flow events and treatment of contaminated water

3.2.6.6 Coastal Sector

With over 3,000 kilometres of coastline along the Atlantic and Indian Oceans, South Africa's coastal and marine environments support a diverse range of ecosystems, economic activities, and social interactions. The coastal zone has a rich diversity of ecosystems, including sandy beaches, rocky shores, estuaries, mangroves, coral reefs, and kelp forests. These ecosystems support a wide array of species, including fish, marine mammals, seabirds and invertebrates, some of which of great economic importance for the country, such as rock lobsters and abalone.

Further, South Africa’s coasts are a magnet for residential and economic activities. About 40% of the population lives within 60 km of the ocean and about 3.5 million South Africans reside within 5-7 km of a coastline (as of 2011); thereof 60% living in densely populated metropolitan areas (Le Roux et al., 2019). Population growth in the coastal zone by far exceeds inland growth rates, especially in KwaZulu-Natal. Further, approximately 60% of the South African economy depends on coastal natural resources. Given that over 95% of the country's imports and exports are transported by sea, trade infrastructure, such as ports, is crucial. Coastal resources are supporting various industries such as fisheries, aquaculture, tourism, shipping and trade, and offshore oil and gas exploration. Coastal tourism is a significant economic driver, attracting visitors to pristine beaches, marine parks, and recreational activities such as diving, surfing, and whale watching. Subsistence and small-scale fishing play an important role in the provision of employment and food security, particularly by providing protein to poor coastal communities.

Coastal spaces are exposed to the “typical” climate hazards also experienced inland, i.e. drought, wildfire, rainfall-related flooding etc. Additionally, climate hazards originating from the ocean threaten coastal infrastructure, livelihoods and the economy. Hazards include sea-level rise, which may result in permanent land loss and inundation, especially in low-lying coastal plains, and extreme events such as coastal storms, causing surges, destructive waves, wind impacts, and coastal erosion. Moreover, climate change also impacts ocean temperatures, salinity, acidity and nutrient distribution. This has been shown to affect ecosystem composition and species distribution along the coast.

Direct impacts include damage to coastal infrastructure and livelihoods, and the disruption of service delivery and economic activities.

Table 3.9 shows the key vulnerabilities and risks for the coastal sector.

Table 3.9. Key vulnerabilities and risks for the coastal sector in South Africa

Sector	Coast
Key vulnerabilities	• Exposure to both, climate hazards originating from the land, such as droughts, extreme rainfalls and wildfires, as well as climate threats originating from the ocean, including sea-level rise, sea storms and on the east coast also an increasing exposure to tropical cyclones • Several metropolitan cities with a high density of population, infrastructure and economic activities and assets are located in the coastal zone, in addition to smaller towns dependent on the coast, e.g. for fisheries and tourism. The high concentration of assets and activities in the coastal zone increases exposure and vulnerability to extreme events. • Coastal population is growing faster than population in other parts of the country. This trend is expected to continue in the next decades, leading to an increasing population being exposed to a climate with more intense and more frequent coastal storms and extreme rainfalls, especially in the eastern part of the country. • The growing coastal population puts tremendous pressure on municipalities in terms of infrastructure development and service delivery, especially water and sanitation. These challenges can result in high levels of social discontent and political instability. • Coastal squeeze: rising sea-levels will ultimately move the coastline further and further inland. Historically, natural environments and settlements were able to "adapt" by transitioning inland in sync with the coastline. However, increasing development density leads to competition for space, thus limiting space for transition. This might lead to ecosystem threatening and dislocation of coastal communities, necessitation "climate migration". • Change in estuary flow regime. Rising sea-levels can change temporarily closed estuaries into permanently open estuaries, while increased river flows and flood events caused by extreme rainfall (especially in the east) can lead to changes in salinity and ecosystem functioning and compositions. This can impact the nursery function for economically relevant fish and crustacean species which might negatively impact the fishing industry. • Dependence of coastal industry on specific natural coastal resources. Small-scale nearshore fisheries are frequently dependent on certain fish species which puts these economies at risk when species migrate away to stay within their ecologically optimal environment. This might also affect e.g. whale and shark tourism, if species abandon historically preferred sighting locations.
Prioritized risks and impacts	• Damage to coastal infrastructure by coastal storms • Increased stormwater exceeding treatment plant capacities and polluting coastal water and beaches, leading to ecosystem damage and negative impacts on beach tourism and fisheries. • Increased flood risk especially in low-lying coastal areas and estuaries

3.2.6.7 Marine sector

The area occupied by South Africa's territorial waters almost equals its terrestrial area. The vast coastal and marine area encompasses five inshore bio-regions, teeming with diverse ecosystems such as rocky shores, estuaries, mangroves, seagrass meadows, coral reefs, and kelp forests. The bioregions for various fauna and flora and the four biogeographical regions of South Africa are shown in Figure 3.9.

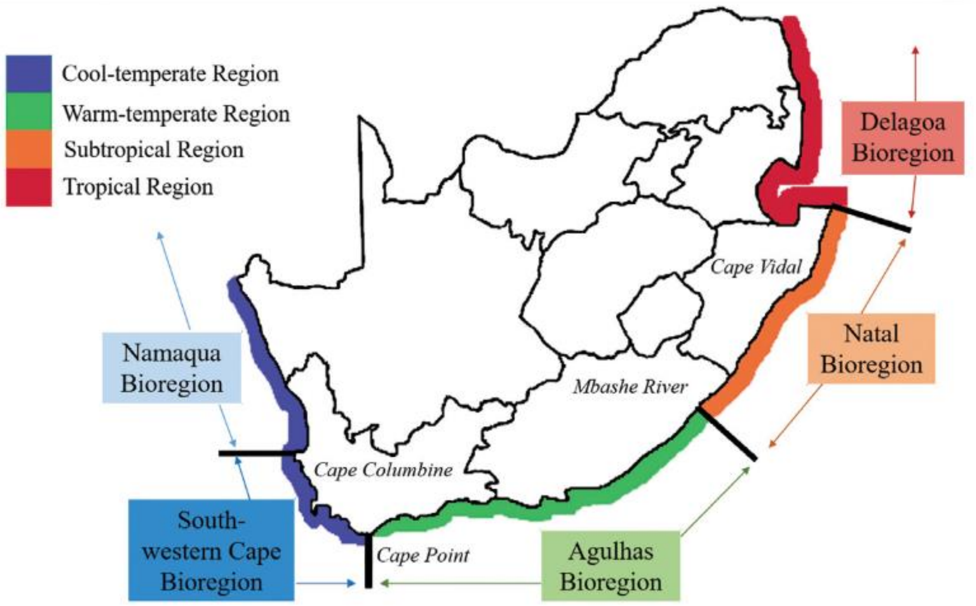

Figure 3.9. The five inshore bioregions for various fauna and flora and the four biogeographical regions of South Africa.

These ecosystems support a wide array of marine species, including fish, marine mammals, seabirds and invertebrates. South Africa's marine sector also plays a crucial role in South Africa's economy, consisting of various industries such as fisheries, aquaculture, tourism, shipping, and offshore mining and oil and gas exploration. South Africa possesses potential offshore oil and gas reserves, particularly along its southern and western coasts. Coastal tourism is a significant economic driver, attracting visitors to pristine beaches, marine parks, and recreational activities such as diving, surfing, and whale watching.

The marine or offshore fisheries sector is dependent on key species such as deep-water hake, shallow-water hake, sardines, and anchovies, among others. Overfishing and stock depletion pose a significant threat to South Africa's marine environment and economy. While some stocks like deep-water hake are showing signs of recovery due to improved management practices, others such as abalone remain severely depleted due to overfishing and poaching. Aquaculture is a growing segment, supported by government initiatives like the Aquaculture Development Zones (ADZs), aimed at boosting production and creating jobs. These zones facilitate investment and infrastructure development to make the sector more competitive.

South Africa’s major fishing grounds are situated along the continental shelf between St Helena Bay and Port Elizabeth. The industry’s major fishing ports, processing factories and service industries are similarly found in the Western Cape. Port Elizabeth, Port St Francis, Durban and Richards Bay are the other ports of significance in this sector outside of the Western Cape. Climate change has already begun to affect South Africa's fisheries, impacting fish stocks, distribution patterns, and the overall sustainability of the sector (DEA, 2013b; Ortega Cisneros et al., 2024; Ramírez et al., 2022; Van der Walt et al., 2021). Some examples include the increasing unpredictability and smaller catch of the once-abundant sardine runs along the KwaZulu-Natal coastline in recent years, impacting fisheries and tourism reliant on these events (Ortega Cisneros et al., 2024). Hake stocks have also decreased due to changes in ocean temperatures and prey availability. The West Coast Rock Lobster too is facing a growing threat from rising water temperatures associated with climate change. The south-eastern warm-temperate coastline of South Africa, which occurs within the Agulhas bioregion, has been identified as a climate change vulnerability hotspot, given its location on the ecotone between the Atlantic and the Indian Ocean circulation systems (DEA, 2013b; Van der Walt et al., 2021). The region is also a hotspot for marine biodiversity, with many endemic species.

Table 3.10 shows the levels of vulnerability of some marine species around South Africa’s south-eastern warm-temperate coastline to climate change according to their upper and lower thermal end-points and habitat temperature.

Table 3.10. Levels of vulnerability of marine species to increased warming and cooling events as a result of climate change according to their upper and lower thermal end-points and habitat temperature on the south-eastern warm-temperate coastline of South Africa . (Van der Walt et al., 2021)

Low vulnerability | Medium vulnerability | High vulnerability

					Parameter	Upper thermal end-point		Lower thermal end-point		Water temperature (°C)		Water temperature (°C)	
						↑ Temperature (°C)	↑ Temperature (°C)	↓ Temperature (°C)	↓ Temperature (°C)	Summer		Winter	
Common name	Species	Illustration	Taxonomic group	Biogeographic affinity	Habitat sampling area	Summer	Winter	Summer	Winter	Max	min	Max	Min
blacktail juveniles	*Diplodus capensis juveniles*		Fish	Temperate	Rock pool	34.5	33.2	8	6.5	25.1	12.8	20.0	13.2
blacktail adults	*Diplodus capensis adults*		Fish	Temperate	Surf zone	28.3		8.4		30.1	14.6	20.8	12.2
strepie	*Sarpa salpa*		Fish	Temperate	Rock pool	33.9	32.4	7.8	7.1	25.1	12.8	20.0	13.2
barred flagtail	*Kuhlia mugil*		Fish	Tropical	Rock pool	37.8	37.1	8.7	8.9	25.1	12.8	20.0	13.2
shrimp	*Palaemon peringueyi*		Macro-invertebrate	Widespread	Rock pool	35.7	34.9	4.7	3.7	25.1	12.8	20.0	13.2
Cape sea urchin	*Parechinus angulosus*		Macro-invertebrate	Widespread	Rock pool	31.3	27	7.0	4.5	25.1	12.8	20.0	13.2
brown mussel	*Perna perna*		Macro-invertebrate	Widespread	Rock pool	38.9	37.9	4.3	4.0	25.1	12.8	20.0	13.2
grooved mullet	*Chelon dumerili*		Fish	Warm-water	Estuarine	37.7	35.6	9.3	5.3	30.1	14.6	20.8	12.2
southern mullet	*Chelon richardsonii*		Fish	Cool-water	Estuarine	34.9	34	5.7	4.6	30.1	14.6	20.8	12.2
Cape stumpnose	*Rhabdosargus holubi*		Fish	Warm-water	Estuarine	35.6	32.3	8.1	5.8	30.1	14.6	20.8	12.2
doublesash butterflyfish	*Chaetodon marleyi*		Fish	Tropical	Estuarine	35.2		11.2		30.1	14.6	20.8	12.2
hermit crab	*Clibanarius virescens*		Macro-invertebrate	Tropical	Estuarine	38.3	38.6	5.6	4.0	30.1	14.6	20.8	12.2
estuarine crab	*Parasesarma catenatum*		Macro-invertebrate	Widespread	Estuarine	39.8	39.2	6.0	4.9	30.1	14.6	20.8	12.2
mud prawn	*Upogebia africana*		Macro-invertebrate	Widespread	Estuarine	38.3	36.2	6.0	4.5	30.1	14.6	20.8	12.2

Table 3.11 shows the key vulnerabilities and risks for the marine sector.

Table 3.11. Key vulnerabilities and risks for the marine sector in South Africa

Sector	Marine sector
Key vulnerabilities	• Unsustainable fishing practices that exceed the ability of fish populations to replenish themselves are a major threat. This is caused by: ○ not adhering to quotas which can deplete fish stocks, ○ Illegal fishing that goes unrecorded or violates regulations. • Destructive fishing practices like bottom trawling that can damage the seafloor habitat crucial for fish reproduction and growth.

Sector	Marine sector
	• Inadequate enforcement of regulations, limited resources for monitoring and control, and a lack of stakeholder participation in decision-making can hinder effective fisheries management. • Habitat loss and degradation: Coastal development, pollution, and destruction of vital habitats like kelp forests and mangroves degrade the marine environment, reducing the capacity to support healthy fish populations. • Offshore oil and gas exploration, increased shipping traffic, and potential for deep-sea mining all pose potential risks to marine ecosystems and fisheries.
Prioritized risks and impacts	• Changes in ocean temperature: Rising sea temperatures affect the distribution and abundance of fish species. Many fish species may migrate to cooler waters, leading to changes in the composition of fish populations in South African waters. Temperate adult blacktail *Diplodus capensis* are unable to tolerate water temperatures above 28.3°C (Van der Walt et al., 2021). There has been an eastward shift in optimal habitat availability for pelagic species in recent decades (Ramírez et al., 2022) • Changes in ocean currents and upwelling: Climate change can alter ocean currents and upwelling patterns, which are critical for nutrient distribution in marine ecosystems. Upwelling intensities have been increasing along the south coast of South Africa (Duncan et al., 2019). Optimal habitats for anchovy, sardine and round herring have decreased in extent on the west coast, whereas optimal habitat availabilities showed slightly positive trends east of Cape Agulhas due to changes in wind and upwelling (Ramírez et al., 2022) • Sea-level rise and coastal habitat loss: Rising sea levels can lead to the loss of critical coastal habitats, such as mangroves, estuaries, and wetlands, which serve as breeding and nursery grounds for many fish species. Coastal erosion and increased storm surges can also damage these habitats, reducing fish populations and impacting the livelihoods of communities that depend on coastal fisheries. • Increased frequency of extreme weather events: Extreme weather events, such as storms and cyclones, can directly damage fishing infrastructure, including boats, gear, and ports. Such events can also disrupt fishing activities, leading to reduced catch opportunities and economic losses for fishers. • Communities dependent on fishing for their livelihoods may face economic challenges due to reduced fish stocks and catch opportunities.

3.2.6.8 Mining Sector

The mining sector in South Africa is one of the country's most critical economic pillars, contributing significantly to GDP, employment, and export earnings. The mining sector contributed about 7.5% to South Africa's Gross Domestic Product (GDP) and directly employed 475,561 people in 2022 (MCSA, 2022). The industry also has a multiplier effect, creating jobs and economic activity in related sectors like transportation, manufacturing, and finance. South Africa is rich in mineral resources and holds the world's largest reserves of platinum group metals (PGMs) like platinum and palladium, and is a major producer of chromium, manganese, and gold. It also has significant reserves of coal and iron ore. Mining activities are concentrated in regions such as

Gauteng, Mpumalanga, Limpopo, and the Northern Cape. South Africa is one of the world's largest producers and exporters of coal, ranking seventh globally in coal production. Coal is the primary source of energy in South Africa, accounting for about 70-80% of the country's electricity generation through coal-fired power plants. Major power plants include Eskom's Medupi and Kusile, which are among the largest coal-fired plants in the world. South Africa's reliance on coal for electricity generation results in high carbon dioxide (CO_2) emissions, making it one of the top emitters on the African continent. The mining sector therefore faces significant challenges related to climate change and environmental sustainability. A just transition framework aims to address these challenges by promoting economic diversification, protecting the livelihoods of workers and communities, and investing in sustainable energy sources.

Climate change poses significant challenges to the mining sector in South Africa, impacting operations, infrastructure, environmental sustainability, and economic viability. Direct impacts relate to operational disruptions, infrastructure damage and health and safety risks. Rising temperatures can lead to more frequent heatwaves and droughts, impacting worker productivity and safety, particularly in underground mines. Additionally, increased water scarcity could disrupt mining operations that rely heavily on water for processing and dust suppression. Water shortages could also force limitations on mining activity in certain regions. Extreme weather events like floods and storms can damage mining infrastructure and disrupt transportation networks crucial for moving minerals to market. The impacts however extend beyond direct operations to indirect impacts such as changes in regulatory requirements, market demand for certain minerals, stricter environmental regulations, carbon pricing as well as disruption in supply chains. Figure 3.10 shows the main types of minerals mined in South Africa.

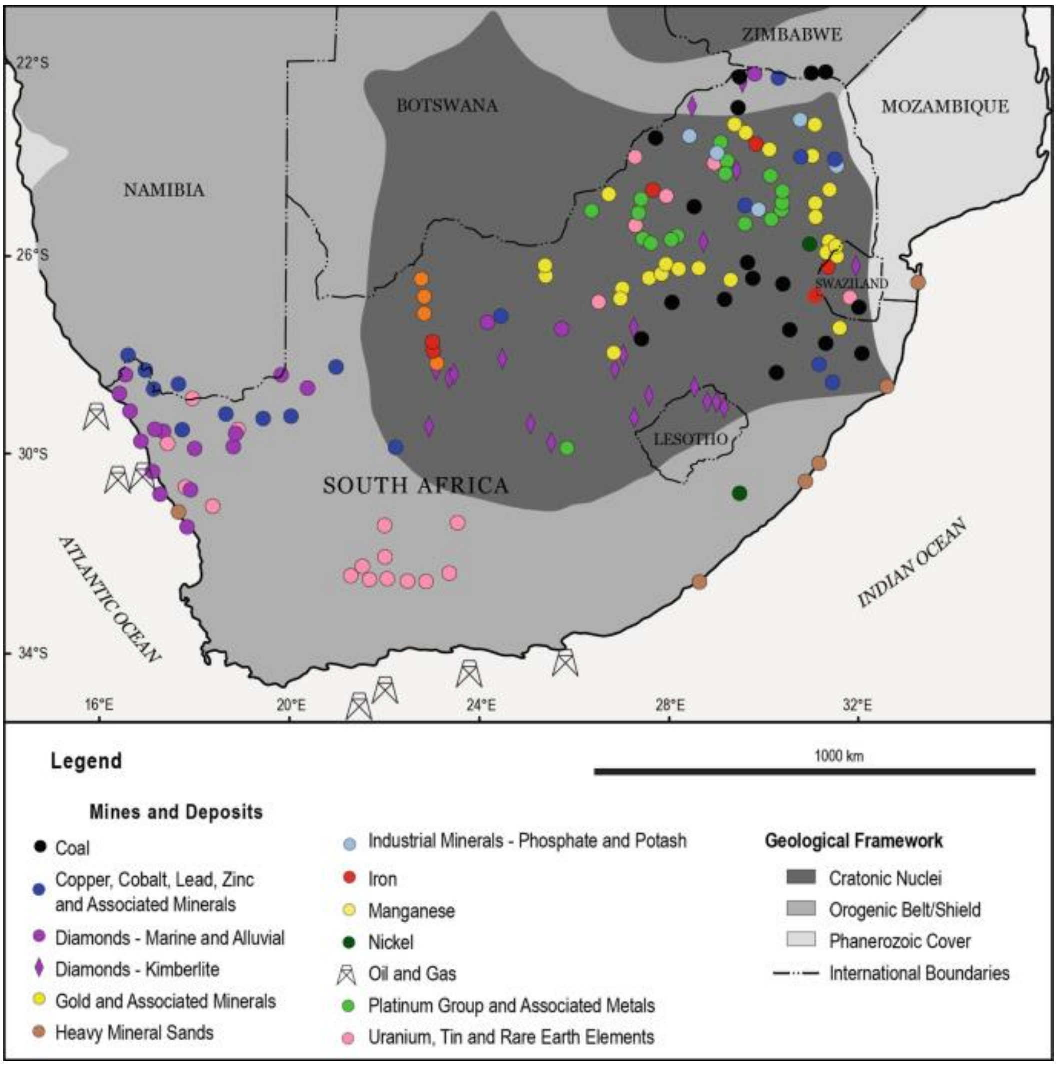

Figure 3.10. Main types of minerals mined in South Africa (Nex and Kinnaird, 2019).

Table 3.12 indicates the provincial percentage change in mining and quarrying sector employment by 2050 for worst case biophysical impacts.

Table 3.12. Provincial percentage change in mining and quarrying sector employment by 2050 for worst case biophysical impacts. (Makgetla et al., 2019)

Sub-sector	Eastern Cape	Free State	Gauteng	KwaZulu-Natal	Limpopo	Mpuma-langa	Northern Cape	North West	Western Cape
2015: Employment (mining and quarrying)	1 000	35 000	105 000	8 000	76 000	61 000	22 000	172 000	3 000
Percentage (%) change in employment – worst biophysical conditions (2050)									
Coal & lignite	-5%			-5%	-5%	-5%			
Gold		-5%	-5%					-5%	
Platinum					-5%	-5%		-5%	
Ferrous minerals					-5%	-5%	-5%		
Non-ferrous minerals					-5%	-5%	-5%		
Other mining & quarrying resources	-5%	-5%	-5%	-5%	-5%	-5%	-5%	-5%	-5%

Table 3.13 shows the key vulnerabilities and risks for the mining sector.

Table 3.13. Key vulnerabilities and risks for the mining sector in South Africa

Sector	Mining
Key vulnerabilities	• Mining activities can have a significant impact on the environment, including air and water pollution, land degradation, and biodiversity loss. Stricter environmental regulations and growing public concern require mining companies to adopt more sustainable practices. These regulations increase mining companies' operating costs, delay the start of new mining projects, slow down production and could also force mines to close. • Climate change carbon regulations have significant implications for the mining sector in South Africa. These regulations are designed to reduce greenhouse gas (GHG) emissions and mitigate climate change impacts, but they also impose various challenges and opportunities for mining companies. • Meeting more strict environmental standards do however improve the reputation of mines, can increase its efficiency, create access to new markets and attract support from local communities.
Prioritized risks and impacts	<u>Direct impacts</u> *Water Scarcity* • Operational disruptions: Mining operations rely heavily on water for mineral processing, dust suppression, and cooling. Prolonged droughts and reduced rainfall can lead to water shortages, forcing mines to reduce or halt production. • Increased costs: Water scarcity drives up the cost of water procurement, requiring investments in water recycling and desalination technologies, which can be expensive. • Regulatory challenges: Increased competition for water resources can lead to stricter water use regulations, further complicating water access for mining operations. *Extreme weather events*

Sector	Mining
	• Flooding: Heavy rainfall and flash floods can inundate mining sites, disrupt operations, damage equipment, and necessitate costly repairs and clean-ups. • Infrastructure damage: Extreme weather events can damage critical infrastructure such as roads, railways, and power supplies, disrupting the transportation of minerals and access to mining sites. *Energy supply challenges* • Reliability of energy supply: Climate change can affect the reliability of electricity supply, especially in a country that heavily depends on coal-fired power plants, which are themselves vulnerable to climate impacts. • Transition to renewable energy: While transitioning to renewable energy can mitigate some climate impacts, it requires significant investment and changes in operational practices. *Health and safety* • Heat stress: Rising temperatures can increase the incidence of heat-related illnesses among mine workers, impacting health and safety standards. <u>Indirect impacts</u> • *Job losses* - The biophysical impact of climate change can lead to as many as 14,700 job losses across all mining industries in South Africa (WWF, 2018). The provinces of Mpumalanga, Limpopo and North-West are most vulnerable. Platinum and gold are expected to lose most direct jobs – platinum is expected to lose 4,900 jobs and gold 3,500 (WWF, 2018). Coal and lignite mining is the most vulnerable and is expected to face close to 6% job losses by 2030. • *Economic and market changes* - Climate change can alter global demand for certain minerals, particularly those related to renewable energy technologies and carbon reduction, impacting the profitability and focus of mining operations. • *Operational costs*: Increased regulatory requirements and the need for investment in adaptation measures can raise overall operational costs. • *Regulatory and policy pressures* - Stricter regulations aimed at reducing carbon emissions and managing environmental impacts can increase compliance costs and necessitate changes in operational practices. • *Carbon pricing* - Introduction of carbon pricing mechanisms can lead to higher operational costs for mines reliant on fossil fuels. • *Social and community impacts* - Water scarcity and environmental degradation can strain relations with local communities, leading to conflicts and opposition to mining activities. • *Supply chain disruptions* - Disruptions in the supply of critical inputs due to extreme weather events or changes in global supply chains can affect mining operations. Extreme weather can disrupt transportation networks, affecting the delivery of mined products to markets and ports.

3.2.6.9 Transportation and infrastructure sector

South Africa has the most extensive transport infrastructure network on the African continent, which supports the mobility of the country's goods and people. This infrastructure includes approximately 750,000 km of roads, approximately 30,000 km of rail tracks of which 20,900 km are route kilometres, eight commercial ports, and 11 principal airports (Mokoena, et al., 2019). Transportation is both directly and indirectly vulnerable to weather and climate impacts. Direct vulnerabilities consist of impacts on physical infrastructure and non-physical impacts on human health, behaviour, and decision-making. Indirect vulnerabilities result from transport's interaction with and dependence on other critical infrastructure and social systems, including water, electricity, information and communication and petroleum systems. Climate change has significant impacts on transport infrastructure and services in South Africa, with a variety of consequences stemming from increased temperatures, changing precipitation patterns, and extreme weather events. The biggest risk arises from physical damage from extreme weather conditions such as flash floods, wildfires, and heat waves. Similarly, coastal infrastructure is at risk from sea level rise and storm surges. According to the South African Institution of Civil Engineering's 2022 Infrastructure Report Card, South Africa's transportation infrastructure is generally in poor condition, particularly road and rail infrastructure (except national roads, heavy haul freight lines, and the Gautrain) and cannot keep up with current demands (SAICE, 2022). It is estimated that the potential impact of climate change in terms of additional annual costs on South Africa's national road network may be as high as USD 96 million in 2030, USD 229 million in 2050, and USD 390 million in 2090, if no adaptation measures are taken (Munera, 2018).

In a study by Lane-Visser & Vanderschuren (2023) that aimed to quantify the volume and economic value of transport infrastructure at risk of weather-related hazards in the City of Cape Town, it was found that the total, transport infrastructure at high risk in the City of Cape Town is valued at R20 billion. Fires and coastal flooding pose the greatest threat. They found that in general, the CoCT's roads are most exposed to fire risks, whilst the MyCiti system is vulnerable to coastal flooding, in particular. Around 15% of rail stations are also exposed to coastal flooding and 43% of rail tracks to fire hazards.

Table 3.14 provides a summary of the total infrastructure value at risk of extreme weather events in the CoCT in 2021 equivalents.

Table 3.14. Total value of infrastructure at risk in the City of Cape Town (2021 billion Rand equivalents). (Lane-Visser &Vanderschuren, 2023)

Risk grouping	Transport infrastructure						Socio-economic infrastructure			Combined
	Roads (rebuild)	MyCiti	GABS	Taxi ranks	Rail (steep slope)	Transport total	Healthcare facilities	Schools	Socio-economic total	Total
High exposure areas	12.11	2.07	0.07	0.99	4.73	19.98	27.02	6.32	33.35	53.33
High risk of coastal floods	1.74	3.05	0.01	0.04	1.26	6.11	1.59	0.31	1.90	8.00
All risk for coastal floods	2.24	3.27	0.02	0.23	1.40	7.16	1.59	0.38	1.97	9.13
High risk of floods	1.29	0.58	0.01	–	0.68	2.56	0.00	0.50	0.50	3.06
All risk of floods	2.18	2.04	0.01	0.02	0.97	5.22	3.18	0.76	3.94	9.16
High fire damage risk	9.05	1.72	0.04	0.14	7.51	18.45	3.19	20.58	23.77	42.22
Simultaneous risk exposure areas	0.07	0.32	0.00	–	0.00	0.39	–	–	–	0.39

R392 million’s (US$21.73 million) worth of transport infrastructure is extremely exposed to climate-related weather events, being in areas that could be affected by multiple climate hazards (Table 3.14). In total, around R20 billion’s (US$1.11 billion) worth of transport infrastructure is in the pre-defined high-risk areas and, as such, subject to significant weather damage. Devastating fires could ruin up to R18.45 billion (US$1.02 billion) in transport infrastructure assets. It is important to remember that these values only pertain to the physical infrastructure and do not take the indirect costs (e.g., loss in productivity and mobility due to reduced access) resulting from the damaged infrastructure into account.

Port operations in South Africa is particularly sensitive to delays caused by weather related events such as strong wind, flooding and storms. Wind is the biggest cause of weather delays at the Cape Town port, with it labelled as the reason behind approximately 89% of all the weather delays (DEDT, 2023). The months of January and December are the most disrupted. The cost of truck delays for all truck owners for the container terminals is, on average, R330 000 per day.

Table 3.15 shows the key vulnerabilities and risks for the transportation sector.

Table 3.15. Key vulnerabilities and risks for the transportation sector in South Africa.

Sector	Transportation
Key vulnerabilities	• Poor road condition are due to inadequate maintenance and funding. Provincial and municipal roads often suffer from potholes, erosion, and general wear and tear. Of the 222,677 km of South Africa's road network, only 48,954 km is paved. Of the paved roads only 39% of the network is deemed to be in a good or very good condition. Only 15% of the gravel network is deemed to be in a good or a very good condition (De Jager & Collins, 2022). • There is a significant backlog in road repairs, with many roads classified as being in poor or very poor condition. • Much of the rail infrastructure is outdated and in need of modernization. • Cable theft and vandalism are significant issues, disrupting services and increasing maintenance costs. • Ports often experience congestion, leading to delays in cargo handling and increased costs. • Poor transport infrastructure disproportionately affects low-income communities, limiting their access to economic opportunities, healthcare, and education
Prioritized risks and impacts	• Storm surges and flooding: Rising sea levels and increased frequency of severe storms lead to higher storm surges, causing flooding and physical damage to port infrastructure, roads and railways. Sea levels around South Africa are predicted to rise by 0.5 to1.4 m by 2100 following a low mitigation scenario (Allison et al., 2022). These increases are around 7%–14% larger than projections of global mean sea level. The eastern part of South Africa is especially vulnerable as predictions indicate the increase in frequency and intensity of category 4-5 tropical cyclones along the east coast of South Africa (Malherbe et al., 2013). The Port of Durban, for instance, experienced significant flooding and infrastructure damage during the storms in April 2022, resulting in extensive repair costs and operational downtime. These impacts are especially concerning considering that about 60%of South African exports go through the port of Durban. • An increase in heavy precipitation and flooding projected over the eastern parts of the country can cause extensive damage to road infrastructure, cutting off access to healthcare facilities, schools, markets, and emergency services. • Enhanced coastal erosion due to stronger wave action and higher sea levels threatens the stability of port structures. This erosion can undermine foundations, requiring substantial investment in coastal defenses and protective measures. • Rising temperatures can lead to the softening and deterioration of asphalt, causing rutting and potholes, leading to increased maintenance costs. The areas of the north-western parts of the country; specifically, along the border between the Northern Cape and North West province with Botswana are most vulnerable where it is predicted that pavement temperatures are expected to be in the vicinity of 70°C by 2050 (Mokoena et al., 2019). Extreme temperature also affect the railway system, with train delays, speed restrictions and equipment or infrastructure failures. • Changes in seasonal characteristics and maximum wind speeds causes delays in loading and unloading of ship cargo and loss of operational hours at ports, especially the port of Cape Town. • More intense and frequent wildfires can destroy transport infrastructure. For example, the 2017 Knysna fires caused significant damage to infrastructure that was estimated at between R4- and R 5 billion. In April 2021 a wildfire on the slopes of Table Mountain in Cape Town caused infrastructure losses of over $100 million (or R1. 5 trillion).

3.2.6.10 Energy sector

South Africa's energy sector is a vital component of its economy, and contributes significantly to economic growth, employment, and revenue generation. Eskom, the state-owned utility, generates approximately 95% of South Africa's electricity and 45% of Africa's electricity (DMRE, 2023). About 45% of all South African end users get their power directly from Eskom, with the remainder resold by redistributors. It does, however, face challenges to maintain a stable energy supply and experiences power cuts and frequent load-shedding. Aging infrastructure and lack of maintenance have led to frequent outages and inefficiencies. Figure 3.11 shows the location of Eskom plants by type.

The country's energy system is heavily dependent on coal which accounted for over 80% of the total power generated in 2022-2023 (DMRE, 2023). Coal is anticipated to remain the primary source of power generation in the short-to-medium term. By 2025, coal-fired power is projected to constitute around 75% of the total, decreasing to about 65% by 2030. In stark contrast, renewables - comprising solar PV, solar thermal, onshore wind, hydro, and bioenergy - represented only about 10% of total generation in 2022. However, this is expected to gradually increase, with renewable energy projected to account for 13% to 17% of the total power generation from 2023 to 2025 and rising to 25% by 2030. These changes align with South Africa's goals for a just energy transition, aiming to ensure energy security and eliminate load shedding (AEC, 2023).

The South African government is adopting policies to support the power sector's transition and address climate risks. To combat energy poverty and expand access to clean electricity, the government launched the Renewable Energy Independent Power Producer Procurement Program (REIPPPP) between 2011 and 2015. The REIPPPP aims to transition the country from conventional energy sources to renewables while also creating jobs, promoting social upliftment, and driving economic transformation. The program has been highly successful, attracting significant private sector investment and expertise into South Africa's grid-connected renewable energy projects at competitive prices. The IRP, part of the National Development Plan (NDP), outlines a framework for future power generation. It aims to add 29,500 MW of electricity capacity by 2030, with significant contributions from wind (14,400 MW) and solar

(6,000 MW). A procurement package announced in 2020 plans for 11,813 MW of new capacity, primarily from renewables, gas, coal, and pumped storage (AEC, 2023; DMRE, 2023).

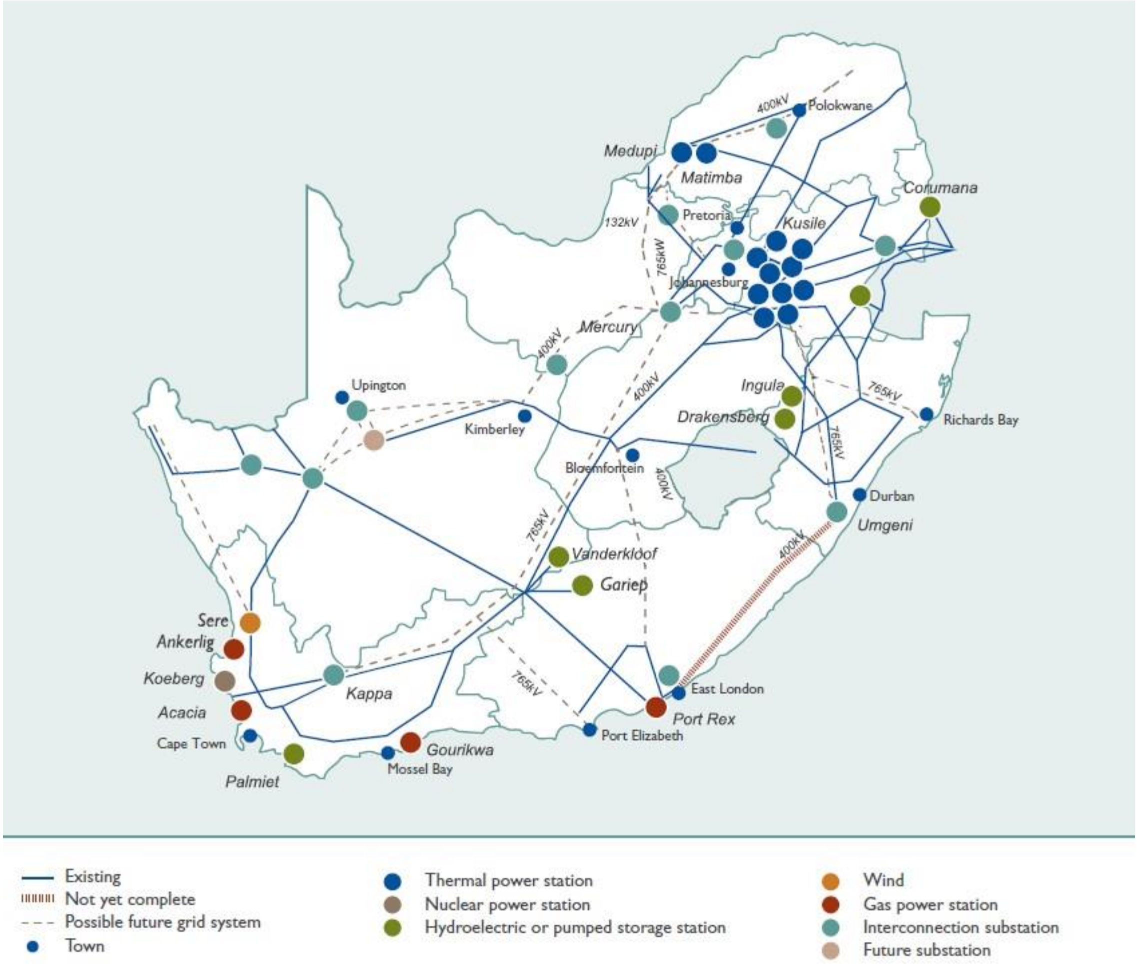

Figure 3.11. Location of Eskom plants by type (Eskom, 2022)

The energy sector faces substantial vulnerabilities to climate change, including water scarcity, extreme weather events, and the environmental and health impacts of coal dependence. Coal-fired power plants, which are the backbone of the current system, are major emitters of greenhouse gasses, severely impacting air quality and contributing to climate change itself. On the Mpumalanga Highveld communities living near these facilities are suffering from respiratory illnesses like asthma and bronchitis. The environmental impact extends beyond air pollution as the process of coal extraction and transportation disrupts natural habitats, leading to water pollution, biodiversity loss and soil erosion.

Furthermore, extreme weather events like droughts and floods, intensified by climate change, can damage power generation infrastructure and disrupt coal transportation networks. Water scarcity, another consequence of climate change, can also impact the cooling systems of thermal power plants and limit hydropower generation. These disruptions can lead to power outages and energy insecurity, hindering economic activity and impacting livelihoods. Table 3.16 shows the key vulnerabilities and risks for the energy sector.

Table 3.16. Key vulnerabilities and risks for the energy sector in South Africa

Sector	Energy
Key vulnerabilities	• Limited diversification in the energy mix, (coal make up 82% of the primary energy supply). Over-dependence on a single energy source makes the country more vulnerable to supply disruptions. • Increasing pressure to reduce greenhouse gas emissions results in stricter regulations on coal-fired power plants, necessitating costly upgrades or even leading to plant closures. • Coal-fired power plants require large quantities of water for cooling and processing, while also polluting water. • The gradual phase-out of coal due to climate and policy pressures can lead to significant job losses in coal-fired power generation sectors • Ageing infrastructure and a substantial maintenance backlog of power plants and distribution systems makes it more vulnerable to extreme climate events. • Infrastructure theft (e.g., copper cable theft) and vandalism are widespread, further weakening the reliability of the power grid. • Existing grid infrastructure requires significant upgrades to accommodate higher levels of renewable energy.
Prioritized risks and impacts	Water Scarcity • Reduced water availability increases competition among agricultural, industrial, and residential sectors, leading to potential conflicts and prioritization issues. Coal mining and power generation together consume 5% of South Africa's water (CER, 2018). Increased temperatures • Higher ambient temperatures decrease the efficiency of coal-fired power plants, as the thermal gradient between the heat source and the cooling medium diminishes. • Prolonged high temperatures can cause thermal stress in infrastructure, leading to increased maintenance costs and more frequent breakdowns. Extreme weather events • Severe weather events, such as floods and storms, can damage coal supply chains and infrastructure. Mines can be flooded, transport routes disrupted, and power plants themselves can be directly affected.

Sector	Energy
	• Extreme weather can hinder the transportation of coal from mines to power plants, leading to fuel shortages and operational interruptions.

3.3 Adaptation priorities and barriers

3.3.1 Adaptation Priorities

South Africa has taken significant strides in recent years to coordinate its climate change research efforts in support of formulating its climate change adaptation strategies (DEA, 2018). South Africa's adaptation goals communicated in its updated NDC comprise the country's contribution to the global goal for adaptation, considering the country's projected risk and vulnerability for the period 2021-2030. These goals are (RSA, 2021):

- Goal 1: Enhance climate change adaptation governance and legal frameworks;
- Goal 2: Develop an understanding of the impacts on South Africa of 1.5 and 2^{o}C global warming and the underlying global emission pathways through geo-spatial mapping of the physical climate hazards, and adaptation needs in the context of strengthening the key sectors of the economy;
- Goal 3: Implementation of NCCAS adaptation interventions for the period 2021 to 2030 (Note: Goals and actions covered in each element contained in the NDC are as per the National Climate Change Adaptation Strategy);
- Goal 4: Access to funding for adaptation implementation through multilateral funding mechanisms;
- Goal 5: Quantification and acknowledgement of the national adaptation and resilience efforts.

The NCCAS is a key policy instrument to guide implementation of adaptation and outline priority areas for adaptation, both to guide adaptation efforts and to inform resource allocation (DEA, 2019). The strategic objectives of the NCCAS are as follows:

- Objective 1: Build climate resilience and adaptive capacity to respond to climate change risk and vulnerability.
- Objective 2: Promote the integration of climate change adaptation response into development objectives, policy, planning and implementation.
- Objective 3: Improve understanding of climate change impacts and capacity to respond to these impacts.
- Objective 4: Ensure resources and systems are in place to enable implementation of climate change responses.

The NCCAS also outlines nine strategic interventions which are required to achieve South Africa's vision to transition to a climate-resilient economy and society, and to which sectoral responses need to be aligned. One of the strategic interventions in South Africa's NCCAS (DEA, 2019) (Strategic Intervention 4) is to "Facilitate mainstreaming of adaptation responses into sectoral planning and implementation". In support of this intervention, Outcome 4.2 in the NAS is to achieve 100% coverage of climate change considerations in sectoral operational plans. The provision of support to private sector businesses to incorporate climate change adaptation into their strategic implementation is one of the proposed actions to achieve this intervention (Action 4.2.5). Developing a National Climate Risk and Vulnerability (CRV) Assessment Framework (DFFE, 2020a), Strategic Intervention 3 in the NCCAS, is intended to guide sectors and provinces when reviewing and revising existing assessments and response plans. This will allow for comparison of the results of the assessments or to support aggregation of the results to provide an overall picture of vulnerability and response across sectors and spheres of government in South Africa.

Priority sectors in the NCCAS include biodiversity and ecosystems, water, health, energy, settlements (coastal, urban, rural), disaster risk reduction, transport infrastructure, mining, fisheries, forestry, and agriculture. The NCCAS identifies interventions to meet adaptation goals. The interventions address both highly vulnerable sectors as well as geographic areas.

Intervention 5 of the NCCAS aims to "promote research application, technology development, transfer and adoption to support planning and implementation" to deliver "increased research output and technology uptake to support planning and implementation". To achieve the above-mentioned intervention, the National Climate Change Adaptation Research Agenda (NCCARA) was developed. The NCCARA is South Africa's adaptation research roadmap, which serves to guide the research on impacts and vulnerability and adaptation options to deliver "knowledge for action", and to support the uptake of this knowledge in adaptation policy and practice. The NCCARA provides prioritization criteria for the research areas for the various sectors, while also outlining the governance and investments implementation framework, and monitoring and evaluation aspects. The NCCARA aims to define the most effective way to build (and in some cases initiate) national investments to address the priority research areas.

The NCCAS includes a set of "enabling" priority actions that would support research. The NCCARA scoping work confirmed that many of these actions were necessary and provided additional insights that can help steer how these should be implemented. Priority enabling conditions for Adaptation Research in South Africa outlined in the NCCARA include:

- Establishing a Climate Change Research Advisory Body
- Setting up a National Climate Centre and National Climate Change Adaptation Research Network
- Establishing an Interactive Online Climate Service Platform
- Continuing and enhancing climate observation and monitoring networks, modelling and projections

The scoping work, and subsequent stakeholder engagement processes, resulted in a large list of both broad and more specific research needs and topics. Given the relatively limited funds that are available for new research, those research needs had to be prioritised so that resources are allocated to the most important knowledge gaps. Short- and medium-term adaptation research needs were prioritised, following which 17 priority research topics for short term commissioning were identified. These were:

1. Climate information and climate service platform development (NCCIS, NFCS Platform, SARVA, NCCRD)
2. Vulnerability of socio-economic value of Ocean and coastal resources to climate change
3. Impacts of climate change on biodiversity and associated benefits for people (socio-economic)
4. Water supply sustainability in drought affected municipalities
5. Cross-border energy generation and water nexus in a changing climate
6. Climate change and health indicators
7. Infrastructure - Road Infrastructure
8. Infrastructure - Water / Dam Infrastructure
9. Biochar in climate smart agriculture and soil rehabilitation
10. Interactions, synergies and trade-offs across systems and sectors
11. Water budget impacts of invaded and bush encroached landscapes
12. Climate impacts on livestock animal health, and appropriate adaptation options
13. Incorporation of climate change into agricultural curricula
14. Agriculture response preparedness for extreme events
15. Projected changes in likelihood, magnitude and duration of climatic extremes, especially flood, drought, heat waves, veld fires etc.
16. Climate change impacts on groundwater
17. Climate impacts on surface water resources, catchment yields, CMA resources and water supply system reliability

3.3.2 Priority Adaptation Sectors

South Africa has embarked on a comprehensive endeavour aimed at laying out clear adaptation priorities and strategies through a sectoral approach. This approach, rooted in sectoral taxonomy, aims to categorise and prioritise adaptation activities according to specific sectors, thereby facilitating targeted interventions and resource allocation (IPCC, 2019). By delineating these sectors and their interlinkages, South Africa advances its adaptation agenda with clarity and purpose. This strategic prioritisation informs policy development, resource mobilization, and collaborative efforts across government, civil society, and the private sector. Through effective communication and mainstreaming implementation of the sectoral approach, South Africa enhances its resilience to climate change while fostering sustainable development for future generations.

The identification of key priority sectors underscores South Africa's commitment to addressing the multifaceted challenges posed by climate change. Agriculture, Commercial Forestry, and Other Land Use emerge as critical sectors due to their susceptibility to climate variability and their significant contributions to greenhouse gas emissions (FAO, 2019). Water Resources, another key sector, faces increasing pressures from climate change-induced shifts in precipitation patterns and water availability (DWS, 2019). Additionally, the Health sector is recognized for its vulnerability to climate-related health risks, including heatwaves, vector-borne diseases, and food insecurity (C&HA, 2020). Biodiversity and Terrestrial Ecosystems represent vital components of South Africa's natural heritage, facing threats from habitat loss, species extinction, and altered ecosystem functions due to climate (SANBI, 2020). Human Settlements, spanning urban, rural, and coastal zones, are particularly vulnerable to climate impacts such as sea-level rise, flooding, and extreme weather events (NPC, 2012). Similarly, Oceans and Coast, integral to South Africa's economy and ecological diversity, confront challenges from ocean acidification, marine pollution, and coastal erosion exacerbated by climate change (DEA, 2019).

Furthermore, the sectoral approach acknowledges the interconnected nature of climate impacts, leading to the identification of cross-cutting sectors. Disaster Risk Reduction and Management play a crucial role in enhancing resilience across various sectors by addressing climate-related hazards and vulnerabilities (UNODRR, 2015). The Energy sector, undergoing a transition towards low-carbon alternatives, is central to mitigating greenhouse gas emissions and building a sustainable energy future (DMRE, 2019). Infrastructure and Transport sectors require climate-resilient planning and investment to withstand climate extremes and ensure continued functionality (SANRA, 2021). Tourism, a cornerstone of South Africa's economy, intersects with multiple sectors, relying on the integrity of biodiversity, resilient human settlements, and sustainable water resources (SAT, 2020). Likewise, the Mining sector faces challenges related to water availability, energy use, and community resilience in the context of climate change impacts (MCSA, 2020). South Africa employs a secondary template for delineating priorities, focusing on the interests served by adaptation actions and their reporting relevance. The National Climate Change Adaptation Strategy (NCCAS) provides a comprehensive framework that mandates adaptation efforts across all levels of government, fostering collaboration among key stakeholders to address the multifaceted challenges posed by climate change (DEA, 2019).

3.3.3 Priority Sector Adaptation barriers

Recognition of the need for adaptation is growing in developing countries, but action has been mostly gradual, incremental, and reactive (IPCC, 2022), which suggests that there are fundamental barriers/obstacles/challenges to the implementation of adaptation policies. Barriers impede the development and mobilisation of adaptive capacity, the implementation of adaptation policies, the engagement of stakeholders, and the use of new frameworks and tools to support adaptation. A barrier to adaptation can be overcome through concrete efforts, creative management, new ways of thinking, prioritisation, and changes in resources, land uses, institutions, and policies. Identifying and removing barriers to adaptation is crucial for reducing adaptation deficits and increasing adaptive capacity (Simões, et al., 2017; Lee, et al., 2022).

Understanding how adaptation barriers arise has become critical to South Africa's climate change policy (Khavhagali, et al., 2023). Moving forward requires an unpacking of barriers as well as the identification of factors that may enable adaptation or assist in overcoming these barriers. Studies by Ziervogel & Parnell, (2014) identified lack of knowledge and understanding as a barrier to adaptation particularly for cities and municipalities in SA. This study found that there is a perception within government and civil society that climate change adaptation is an environmental and development (i.e., economic, social, political and sustainability) issue, resulting in disaster risk management being slow in linking risk reduction to extreme events to climate change impacts. Furthermore, roles and responsibilities of all spheres of government were identified as another barrier that impedes adaptation where there is often ambiguity as to who is responsible for adaptation (Ziervogel & Parnell, 2014). This ambiguity spreads across these spheres inhibiting climate change adaptation action on the ground. Part of the challenge is that there is not adequate engagement and interaction between the three spheres of government (national, provincial, and local) around the various roles.

Recent studies by Sibiya et al., (2023) and Khavhagali et al. (2024) focussed on an analysis of the barriers to climate change adaptation in South Africa and identified various barriers that impede adaptation in SA, through interviewing government officials working on climate change adaptation. These officials were specifically asked to outline key challenges that exist in developing and implementing climate change adaptation policies, strategies, and programmes at all three spheres of government (i.e., the national, provincial, and local government levels).

Barriers highlighted by Sibiya et al., (2023) and Khavhagali et al. (2024) included limited understanding of climate change issues by communities, limited political will, lack of climate change knowledge by some staff members tasked with environmental duties, not enough climate change plans in place at the local level, inadequate coordination across government levels and sectors, no climate change unit at the local level, no legal mandate at the local level, outdated information on climate change issues used in the IDPs, inadequate financial resources, and lack of human resources. The two predominant barriers to climate change adaptation in South Africa are inadequate financial resources, which are cross-cutting across all three government levels, and a lack of human capacity at the provincial and local levels (Sibiya et al., 2023).

It was clear that there is a need for solutions to address these barriers, such solutions include clear mandate, will, and prioritisation of adaptation actions; co-creation and partnerships and collaboration; and awareness and communication were rated equally, followed by alignment. Implementation and capacity were rated the lowest. There is a consensus that the barriers indicated above are deterring the implementation of adaptation in the country. Mandate, collaboration, and partnerships as well as awareness and communication are further regarded as enablers of adaptation. Issues of barriers and enablers need to be addressed in the adaptation policy.

At a provincial level, barriers that impact the level of implementation of plans and strategies on the ground were outlined in the 2024 Draft SANAs report. Several common provincial barriers related to service provision, availability of resources, data availability, monitoring and evaluation, available capacity, etc. are outlined in Figure 3.12.

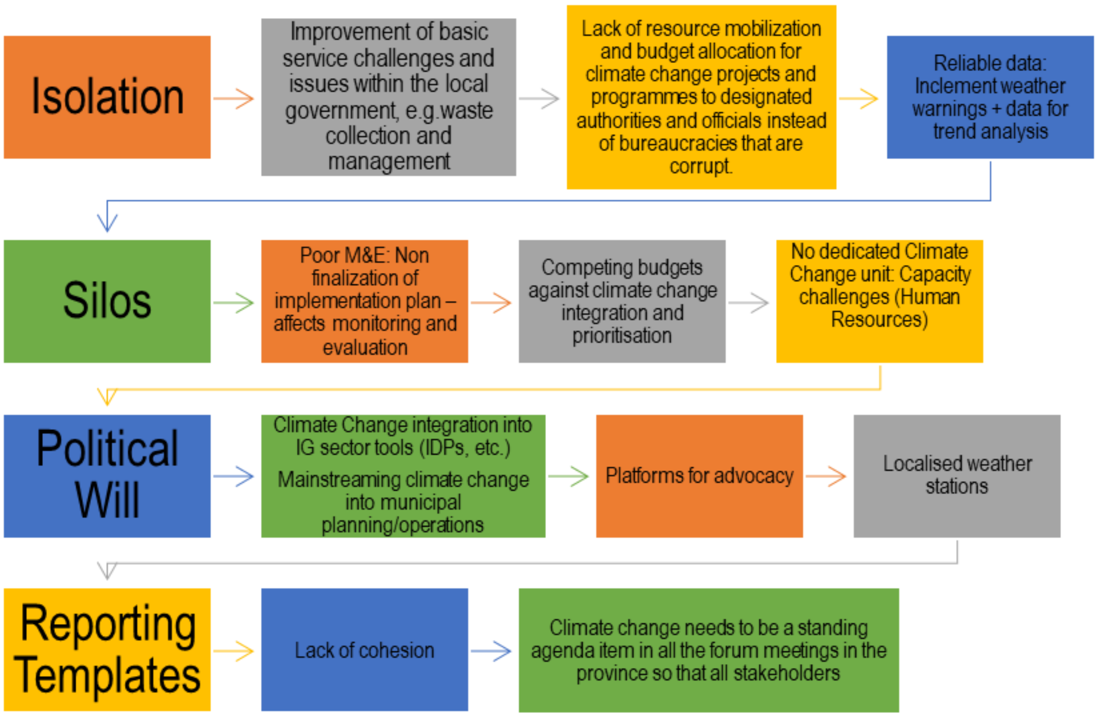

Figure 3.12. Common provincial barriers to implementation of climate action (DFFE, 2024)

3.4 Adaptation strategies, policies, plans, goals and actions to integrate adaptation into national policies and strategies

3.4.1 Adaptation strategies, plans and goals

This section outlines adaptation actions and progress on policies, plans, strategies and frameworks that support climate change adaptation per sector in Table 3.17 to

Table 3.27.

Table 3.17: Adaptation actions and progress on key policy, strategy and legislation per sector: Agriculture

Sector	Agriculture
Adaptation actions	• Actionable Guidelines for the Implementation of Climate Smart Agriculture in South Africa: This practical document provides detailed guidance on climate-resilient practices for farmers. The Agricultural Research Council (ARC) of South Africa has developed a Climate Smart Agriculture guide to assist farmers, agricultural practitioners, and policymakers in adopting climate-smart agricultural practices. It provides evidence-based research and case studies that have been conducted in South Africa to help stakeholders understand and implement strategies that enhance agricultural productivity, resilience, and sustainability in the face of climate change. • Research and innovation: The ARC together with academia and other research institutions in South Africa is investing in research and development to create climate-resilient crop varieties, livestock breeds, and innovative farming practices. They are developing drought-tolerant and heat-resistant crop varieties and livestock breeds. • Sustainable natural resource management: Conservation agriculture in South Africa is promoted by the Conservation Agriculture Policy (2022) aimed at promoting sustainable farming practices that improve soil health, enhance agricultural productivity, and increase resilience to climate change. • Capacity Building and Education: The agricultural sector is strengthening agricultural extension services to disseminate knowledge and technologies to farmers. The sector is also implementing training programs to build farmers' capacities in climate adaptation techniques and sustainable practices. • Institutional Frameworks: The agricultural sector has developed several climate change adaptation plans and strategies which has been integrated into national and regional agricultural policies and development plans.
Progress on key policy, strategy	• **Draft Conservation Agriculture Policy (2022):** To promote and establish ecologically and economically sustainable agricultural systems to increase food security. The draft Conservation Agriculture Policy has been developed and is currently undergoing approval processes for Cabinet ratification. • **Climate Smart Agriculture Strategic Framework (2018)** which outlines the CSA measures in combating problems facing the South African agricultural sector that relate to climate change, the Department of Agriculture, Land Reform and Rural Development has developed sector response measures that includes climate change adaptation and mitigation programmes focusing mainly

Sector	Agriculture
and legislation	on enhancing the resilience of farmers, food and agricultural production systems, reducing agricultural greenhouse gas emissions while ensuring national food security. • **Carbon Tax Act 15 of 2019**: The Carbon Tax Bill was implemented on 1 June 2019. Agriculture and other land use and waste sectors are exempted from direct greenhouse gas emission taxes during the first phase of implementation; however, indirect taxes will apply for fuel and energy usage. • **The Draft Climate Change Bill** (the Climate Change Bill was signed into law by the President of South Africa on 23 July 2024) sought to establish a legislative framework for addressing climate change in South Africa, with specific implications for agriculture in terms of: • Emission Reduction Targets: Sets targets for reducing greenhouse gas emissions in the agricultural sector. • Adaptation Strategies: Mandates the development and implementation of climate adaptation strategies at the national, provincial, and local levels. • **Monitoring and Reporting**: Requires agricultural stakeholders to monitor and report emissions and climate adaptation activities.

Table 3.18: Adaptation actions and progress on key policy, strategy and legislation per sector: Forestry

Sector	Forestry
Adaptation actions	• Fire Management: Implementing firebreaks, controlled burns, and early detection systems to manage wildfire risks. • Water Conservation: Enhancing water use efficiency and developing drought-resistant tree species. • Pest and Disease Management: Monitoring and controlling pest populations and investing in research for disease-resistant tree varieties. • Sustainable Practices: Promoting sustainable forest management practices to maintain soil health and biodiversity. • Policy and Planning: Integrating climate change considerations into forestry policies and land use planning to enhance resilience.
Progress on key policy, strategy and legislation	• Act No. 13 of 2023: National Veld and Forest Fire Amendment, Act 2023. • The National Forests Amendment Act, No. 1 of 2022.

Table 3.19: Adaptation actions and progress on key policy, strategy and legislation per sector: Biodiversity and Ecosystems

Sector	Biodiversity and Ecosystems
Adaptation actions	• Protected Area Expansion and Connectivity: Enhances biodiversity resilience by expanding the network of protected areas (including marine protected areas) and establishing ecological corridors to facilitate species movement. Over the 2014- 2022 period, 163 411 ha of terrestrial biodiversity were added to National Parks and 229 519 ha of marine areas through three newly declared Marine Protected Areas (SANParks, 2023). • Habitat Restoration and Rehabilitation: Implement habitat restoration projects to enhance the resilience of degraded ecosystems and promote biodiversity recovery. Restore key habitats such as fynbos, grasslands, and wetlands through invasive alien plant removal, reforestation, and soil conservation measures. Ecological restoration programs from DFFE, such as Working for Water (WfW) and Working for Wetlands, have contributed significantly to alien plant removal and rehabilitation. To date, Working for Water has cleared over 3 million hectares of invasive plants and Working for Wetlands rehabilitated 634 wetlands across the country, constituting approximately 22 500 hectares. • Integrated Water Resource Management (IWRM): Implementing IWRM in South Africa is complex but essential to ensure sustainable and equitable water resource management. IWRM is implemented through catchment management agencies, water user associations, water stewardship programs, and ecosystem protection and rehabilitation to improve water efficiency and enhance water security in the face of climate change. Implementation challenges include capacity constraints at all levels of government, coordination and integration inefficiencies among sectors, data and information gaps impeding effective decision-making, and climate change. While there are significant challenges, ongoing efforts to improve policy, strengthen institutions, enhance stakeholder participation, ensure financial sustainability and invest in data and monitoring systems are crucial. By promoting integrated approaches and adaptive management, South Africa can better manage its water resources in the face of growing demands and environmental and climate changes. • Climate-Smart Land-Use Planning: Integrate climate change considerations into land-use planning and decision-making processes to minimise habitat loss, fragmentation, and degradation. This includes mainstreaming climate adaptation across sectors and incorporating ecosystem-based approaches into adaptation planning. • Biodiversity Stewardship and OECMs: South Africa's National Protected Area Expansion Strategy aims to achieve cost-effective, protected area expansion for improved ecosystem representation, ecological sustainability, and resilience to climate change. Biodiversity stewardship is currently the primary tool for expanding the country's conservation estate. Biodiversity stewardship involves securing land in priority areas through voluntary agreements with private landowners, Communal Property Associations, and community members. To increase biodiversity stewardship, South Africa is in the process of institutionalizing. Other Effective Area-Based Conservation Measures (OECM) into its existing policy frameworks and aligning OECMs with the biodiversity stewardship community of practice. This would facilitate fully integrating all OECM initiatives across South Africa into biodiversity stewardship agreements. This is essential in involving communities in conservation and building climate change resilience across South Africa. • Ecosystem-based Adaptation (EbA): Implement ecosystem-based adaptation strategies that harness ecosystems' natural resilience to climate change. Examples of EbA projects in South Africa are the Natural Resource Management Programmes (e.g) Working for Water, Working on Fire, and Working for Ecosystems, etc.) as they couple ecosystem restoration and sustainable community development while considering anticipated climate change impact trends to reduce vulnerability and improve the resilience of ecosystems and communities. Between 2020-2022, the South African government invested over 1.5 billion Rand to address biological invasions, mainly in rural areas, for job creation (SANBI and CIB, 2024). SANBI is

Sector	Biodiversity and Ecosystems
	spearheading EbA work in South Africa, from creating guidelines to producing EbA priority maps and building communities of practice regarding EbA and restoration work. • Community-Based Conservation: Engage local communities in biodiversity conservation and climate adaptation efforts through participatory approaches, capacity building, and sustainable livelihood initiatives. Examples of this include EbA projects, biodiversity stewardship agreements and training programs for farmers on climate-smart agriculture practices. Climate-smart agricultural practices enhance agricultural resilience while minimising negative impacts on biodiversity and ecosystems. These practices include agroforestry, conservation agriculture, and sustainable land management practices. • Research and Monitoring: Monitor changes in species distributions, habitat conditions, and ecosystem dynamics to identify emerging threats and prioritize conservation interventions. South Africa, through the NRF, DSI, and multiple other research organizations and funding partners, conducts monitoring programs and research initiatives to assess the impacts of climate change on biodiversity and ecosystems. This data helps inform conservation strategies, prioritize actions, and track the effectiveness of adaptation measures. • Mainstreaming Biodiversity into Business and Nature-related Financial Disclosures: Nature is essential for the economy, financial stability, and society's resilience, yet many companies do not consider their impacts and dependencies on nature and the risks and opportunities related to their organisations. The WEF reported that environmental-related risks will be among the most severe risks on a global scale over the next ten years, exposing businesses to increasing risks (WEF, 2022). Initiatives and frameworks such as the biodiversity sector investment portal, TCFD, TNFD, WWF Risk Filter Suite, and NBBN are a great start at getting businesses involved in nature conservation and enabling private investment in climate adaptation.
Progress on policy, strategy and legislation	South Africa has strengthened its policy frameworks, legislation, and institutional capacity for climate adaptation and biodiversity conservation at the national, provincial, and local levels. These include: • National Biodiversity Framework 2019 - 2024: The NBF introduces new strategic priorities that align with contemporary conservation challenges and international commitments, such as the Sustainable Development Goals (SDGs) and the Paris Climate Agreement. The new framework emphasises addressing climate change's impacts on biodiversity and incorporating climate resilience into biodiversity planning and actions. • National Climate Change Adaptation Strategy (NCCAS) 2019: The NCCAS, which serves as South Africa's National Adaptation Plan, provides a comprehensive framework for climate adaptation across various sectors, including the biodiversity sector. It outlines priority adaptation interventions and serves as a guideline for integrating climate resilience into planning and decision-making processes at all levels of government. One of the guiding principles of these strategies is to promote the protection of ecosystems and biological diversity because of their role in supporting South Africa's adaptation to climate change. • Nationally Determined Contribution (NDC) Update 2021: South Africa updated its NDC under the Paris Agreement, committing to more ambitious greenhouse gas (GHG) emission reduction targets. The updated NDC includes ecosystem-based mitigation and adaptation components, reflecting the country's enhanced commitment to addressing climate change. • Climate Change Bill: The bill aims to provide a legislative framework for effectively managing climate change impacts in South Africa. It will ensure that climate action is coordinated across all levels of government, fostering a comprehensive and integrated approach to climate resilience. The bill anchors South Africa's climate change response in law and mandates the development of climate change response strategies and action plans focusing on climate mitigation and adaptation. It also gains the authority to implement more ambitious measures outlined in the NDC.

Sector	Biodiversity and Ecosystems
	• National Biodiversity Strategy and Action Plan (NBSAP) 2015-2025: This plan identifies the priorities for biodiversity management in South Africa and aligns them with global priorities and targets. The new NBSAP includes more comprehensive strategies for addressing the impacts of climate change on biodiversity, promoting adaptation and mitigation measures. It also emphasises the importance of building social and ecological resilience to cope with climate change impacts. • National Environmental Management: Biodiversity Bill: Currently out for comments, this bill aims to enable the implementation of international agreements and provide appropriate measures in response to climate change. The bill emphasises the conservation and restoration of ecosystems that are crucial for buffering the impacts of climate change, integrates climate change considerations into biodiversity planning and management, and fosters collaboration between different sectors and government agencies to ensure that biodiversity and climate change policies are aligned and mutually reinforcing. • Further, SANBI and DFFE recently drafted Biome-Level Implementation Plans For The Biodiversity And Ecosystems Sector Climate Change Adaptation Strategy • DFFE is currently developing the Climate Change Adaptation Response Plan for South Africa's Coastal Sector which will include adaptation response for the natural coastal environment. Biodiversity Management Agreements (BMA): NEMBA provides for the development of Biodiversity Management Plans (BMP) for species. A Biodiversity Management Agreement aims to allow a person or organisation to manage a species or ecosystem through an approved Biodiversity Management Plan (BMP), valid for five years. In 2024, South Africa developed and implemented its first BMA, which was enabled by tax incentive section 37C (1) of South Africa’s Income Tax Act, which is dedicated to the environment. These BMAs could become OECMs, further contributing to expanding conservation areas and meeting the country’s NDC and GBF targets.

Table 3.20: Adaptation actions and progress on key policy, strategy and legislation per sector: Health sector

Sector	Health Sector
Adaptation actions	South Africa's health sector is taking steps to adapt to the challenges posed by climate change. Here are some key strategies with examples and progress updates: **1. Early Warning Systems and Surveillance:** • **Strategy:** Develop and implement early warning systems for extreme weather events, vector-borne diseases, and heatwaves. • **Example:** Implementing weather forecasting systems combined with disease modeling to predict and prepare for outbreaks of climate-sensitive diseases like malaria and dengue fever. The South African National Institute for Communicable Diseases (NICD) monitors weather patterns and disease outbreaks, issuing early warnings for malaria and other climate-sensitive diseases. • **Progress:** South Africa already has established systems for forecasting extreme weather events. However, integrating these with disease forecasting requires further development. **2. Climate-Resilient Infrastructure:**

Sector	Health Sector
	• **Strategy:** Invest in climate-resilient health infrastructure, including water and sanitation systems that can withstand extreme weather events and ensure access to clean water. invest in renewable energy sources for backup power. • **Example:** Upgrading sanitation facilities to better withstand floods and droughts, ensuring access to clean water during extreme weather events. Upgrading healthcare facilities with heat-resistant roofing and backup power can improve their resilience to heatwaves and power outages. Western Cape Department of Health has been piloting the Municipal Risk Pooling (MURP) that will improve the capacity of municipalities to better plan, prepare, and respond to extreme weather events and natural disasters. • **Progress:** Limited progress has been made. Investment is needed to improve infrastructure in vulnerable communities Limited progress has been made in mainstreaming climate resilience into infrastructure development **3. Strengthening Healthcare/health workforce Capacity:** • **Strategy:** Train healthcare workers to identify, diagnose, and treat climate-related health problems, incorporate climate change considerations into medical curriculums, and build capacity for community health education • **Example:** Training healthcare workers to diagnose and treat climate-related illnesses, like heatstroke and waterborne diseases. Including climate change modules in medical training programs can equip future healthcare professionals with the necessary knowledge and skills. • **Progress:** The Department of Health offers some training programs, but more resources are needed to equip healthcare workers across the country and integrating climate change into health worker training. the South African Medical Association (SAMA) offers training programs on climate change and health for medical professionals. **4. Community Engagement and Education/community-based adaptation:** • **Strategy:** Empower communities to prepare for and respond to climate change impacts on health through education, awareness campaigns, and capacity building. This can involve promoting rainwater harvesting, improving sanitation practices, and supporting local food production systems. • **Example:** Educating communities about the health risks of climate change and how to protect themselves, such as promoting safe water storage and vector control practices. Community health workers can play a crucial role in educating people about heatstroke prevention, water safety, and the importance of using mosquito nets. The South African Red Cross Society works with communities in vulnerable areas to develop climate resilience plans. These initiatives show promise but require scaling up and long-term support. • **Progress:** Some community health initiatives exist, but broader public education campaigns are necessary; more resources and support for long-term sustainability **5. Climate-Smart Health Research:** • **Strategy:** Invest in research on the health impacts of climate change in South Africa, including developing evidence-based interventions and adaptation strategies. • **Example:** Researching the potential expansion of vector-borne diseases and developing local solutions for prevention and control. • **Progress:** Research is ongoing, but more funding and collaboration are needed to address knowledge gaps and develop effective adaptation strategies specific to the South African context. **6. Social Protection Programs:**

Sector	Health Sector
	• **Example:** Providing social safety nets, such as food assistance and temporary housing, for communities affected by extreme weather events to reduce health risks associated with malnutrition and displacement. • **Progress:** South Africa has existing social welfare programs, but strengthening them to address climate shocks is crucial. **7. Research and Innovation:** • **Strategy:** Invest in research on climate-sensitive diseases, develop heat-resistant crops for food security, and explore new technologies for telemedicine and remote healthcare delivery. • **Example:** The South African Medical Research Council (SAMRC) is conducting research on the impact of climate change on malaria transmission. Research efforts are ongoing, but more funding and collaboration are crucial for impactful innovation. **Overall Progress:** • South Africa has developed a national climate change adaptation strategy (NCCAS) that outlines steps for the health sector. However, implementation requires significant investment and collaboration across different government departments and stakeholders. The National Climate Change and Health Adaptation Plan (NCCHAP) is currently being updated. • The South African Medical Research Council (SAMRC) Climate Change and Health Research Programme funds research on the health impacts of climate change in South Africa, addressing issues such as malaria transmission, health risks associated with heatwaves and mental health impacts. • Climate-Based Health Services Project (CHBS), piloted in the KwaZulu-Natal province, uses climate forecasts to predict malaria outbreaks and guide public health interventions. • Training Initiatives on climate change and health for healthcare workers are offered by several organizations such as South African Medical Association (SAMA), Red Cross Society and Department of Health: • **Community-Based Adaptation Projects by s**everal NGOs and government agencies working with communities in vulnerable areas to develop climate resilience plans
Progress on policy, strategy and legislation	Progress on existing frameworks and some developments include: **1. National Climate Change Adaptation and Health Adaptation Plan (NCCHAP) for Health (update in progress):** This plan aims to be a comprehensive framework outlining how the health sector will adapt to climate change (https://www.unisdr.org/preventionweb/files/57216_nationalclimatechangeandhealthadapt.pdf). 2. **National heat-health guidelines** The purpose of the guidelines is to ensure that the health sector is prepared to effectively respond to rising temperatures across South Africa. https://www.health.gov.za/wp-content/uploads/2022/06/National-Heat-Health-Action-Guidelines.pdf **3.** Revised National Health Research priorities (2021-24) indicates the need to assess the individual, synergistic and cumulative health effects of major global and local events and processes, including extreme weather events (drought, floods, heat waves, wildfires) associated with climate change. Climate change is also mentioned as a global, planetary and national catalysts and contextual process https://www.health.gov.za/wp-content/uploads/2023/06/Revised-National-Health-Research-Priorities-2021-2024.pdf

Sector	Health Sector
	4. National Climate Change Response White Paper (2023) emphasizes the importance of building climate resilience across various sectors, including health. It highlights the need for investing in early warning systems for health risks, improving water and sanitation infrastructure, and integrating climate considerations into health workforce training https://www.dffe.gov.za/sites/default/files/legislation/2023-09/national_climatechange_response_whitepaper_0.pdf. **5. Integration of Climate Change Considerations into Existing Health Policies and plans indicates that** there is a gradual integration of climate change considerations into existing health policies. Provincial health departments, for instance, are starting to address climate risks within their strategic plans. This highlights a growing recognition of the importance of adaptation within the health sector. **6. Provincial and Local Initiatives:** Several provincial health departments and local municipalities are taking initiative. Examples include **Heat Health Action Plans for Cities** to protect vulnerable populations during extreme heat events. **7. Advocacy and Capacity Building:** Organizations like the Climate and Health Alliance of South Africa (CHASA) are playing a crucial role. They advocate for policy change, conduct research, and provide training for healthcare workers, building capacity within the sector to address climate challenges (https://phasa.org.za/index.php/special-interest-groups/13-climate-energy-and-health). **8. Focus on Early Warning Systems and Climate Information Services:** The South African National Institute for Communicable Diseases (NICD) are constantly improving early warning systems for climate-sensitive diseases like malaria and using climate data to predict outbreaks and take preventive measures. (National Institute for Communicable Diseases (NICD) website) **9. Capacity Building for the Health Workforce:** Organizations like the South African Medical Association (SAMA) offer Training programs and workshops on climate change and health, aiming to equip healthcare professionals with the knowledge and skills to identify and manage climate-related health issues. (South African Medical Association (SAMA) website)

Table 3.21: Adaptation actions and progress on key policy, strategy and legislation per sector: Human Settlements

Sector	Human Settlements
Adaptation actions	• A spectrum of adaptation actions is at the disposal of local municipalities to enhance resilience and mitigate risks posed by changing climatic patterns and extreme weather events. Some of the categories of actions include: • Infrastructure development, encompassing the construction of, for example, seawalls, levees, and storm surge barriers to protect against rising sea levels and extreme weather events. These engineered solutions provide immediate protection and buy time for longer-term adaptation efforts but are mostly very expensive to build. • Green infrastructure initiatives offer sustainable and nature-based solutions. Municipalities can implement urban green spaces, green roofs, and permeable pavements to absorb excess

Sector	Human Settlements
	water, reduce flooding, and mitigate the urban heat island effect. Such approaches not only enhance climate resilience but also contribute to improved air quality and overall urban liveability. • Environmental protection such as restoring ecosystems like mangroves, dunes, and wetlands, not only provides natural buffers but also supports biodiversity. • Integrated urban planning is essential to create climate-resilient municipalities. Land-use regulations should be adapted to consider climate risks, prioritising construction practices that enhance resilience. Elevating structures above projected flood- and sea levels and using climate-resilient materials in building design can minimise the impacts of flooding and storm damage. • Early warning systems and emergency preparedness plans are critical tools to ensure swift responses to extreme weather events, minimising the impact on vulnerable communities. • Innovative water management strategies are essential for municipalities facing changing precipitation patterns and increasing water scarcity. Diversifying water sources, implementing water efficiency measures, and investing in advanced stormwater management systems contribute to water security and sustainable resource use. • Engagement and education are pivotal components of successful adaptation strategies. Empowering officials, and residents, to understand and respond to climate risks through awareness campaigns, education programmes, and participatory planning initiatives can enhance local adaptive capacity (Van Niekerk, 2024). • Local governments must embrace a combination of structural, natural, and community-based approaches to build resilience and adaptive capacity, protect vulnerable communities, while ensuring long-term sustainability in the face of evolving climate challenges.
Progress on policy, strategy and legislation	• Climate Change Bill • Disaster Management Act, Act 57 of 2002. • Integrated Urban Development Framework, 2016. • National Development Plan • National Spatial Development Framework • Spatial Land Use Management Act (SPLUMA), Act 16 of 2013. • Priority Settlement and Housing Development Areas Climate Risk Profiles and Climate Response Plans • Climate Adaptation response Plan for South Africa's Coastal Sector (draft June 2024)

Table 3.22: Adaptation actions and progress on key policy, strategy and legislation per sector: Water

Sector	Water
Adaptation actions	• Possible measures that can be implemented to adapt to the increased risk of flooding, include: • The construction of flood barriers, • the preservation of natural wetlands or the construction of artificial wetlands in order to effectively attenuate flood waters, • the development and implementation of flood early warning systems, • the revision of engineering design criteria for future infrastructure development, design infrastructure to minimize increased flood risk: Future infrastructural development needs to include the increase of storage capacity to allow for more floodwater to be captured and stored. This can include underground storage where more water may be stored for future use. This will reduce human vulnerability to the impacts of floods while reserving these extremely high volumes of water for use in drier periods and also for groundwater recharge, • improving the maintenance of structures (particularly keeping them free of debris to minimize blockages), and the development of sustainable urban drainage systems (SUDS) • Possible measures that can be implemented to adapt to the increased risk of droughts, include: • Implementing the water conservation and water demand management (WCWDM) strategy which will contribute towards improved water use efficiency and water security. Particularly, reducing urban leaks is a priority, as approximately 37% of the water from reticulation systems is lost to leaks or illegal connections i.e. non-revenue water (McKenzie et al., 2012). • The use of groundwater: groundwater is underutilized and where feasible is likely to be cheaper and more environmentally friendly (considering energy requirements) than large scale desalination (DWA, 2010). • Clearing alien invasive plants is a strategy to counter drought and can also contribute to the creation of employment • Rainwater harvesting offers a more decentralized form of water supply and is ideal for areas that are far from other water sources where water transfer costs would be high. • Other adaptation measures include: • Ecosystem-Based Adaptation (EbA): ecosystem-based adaptation strategies can harness the natural resilience of ecosystems to climate change • Monitoring and Research: Monitor changes to groundwater, surface water, aquatic ecosystems to identify threats and responses to climate change • Research viability of increasing water storage and transfer infrastructure schemes • Improving water use efficiency and reducing NRW also help in reducing energy demand • Exploring opportunities for generating hydropower within existing water systems • Wastewater Treatment Plants can be adapted to capture biogas and generate electricity. • Catchment restoration which potentially assists in improving water security and reduces soil erosion
Progress on policy, strategy and legislation	• The National Water Resources Strategy 3rd Edition (2023) • Water and Sanitation Sector Policy on Climate Change (2017)

Table 3.23: Adaptation actions and progress on key policy, strategy and legislation per sector: Coastal Sector

Sector	Coast
• **Adaptation actions**	• Conduction of location and climate hazard-specific risk assessments: In contrast to e.g. droughts or extreme temperatures which affect larger regions, coastal climate hazards such as flooding, and erosion typically occur very localised. The first action should therefore be to establish which areas are exposed to climate threats? Which settlements, communities and infrastructure are exposed and which are inherently vulnerable? • Priorization of places and climate risks for actions. Adaptation actions can include: • Development and enforcement of Coastal Management Lines which prevent development in risk-prone coastal areas. Similarly, development of risk lines for other climate hazards (e.g. the typical 1:50 and 1:100 years flood lines for river flooding) • Protection, restoration and maintenance of coastal green infrastructure, such as dunes and coastal vegetation as buffer for coastal floor and erosion impacts • Development of engineered coastal protection structures such as seawalls. • Upgrading of stormwater systems to prevent flooding after extreme rainfall events • Restoration of riverine vegetation and wetlands for better stormwater absorption and purification • Development of green urban infrastructure for flood water infiltration, such as rain gardens, vegetated storm water swales • Climate-wise buildings and infrastructure: develop building codes and guidelines obligatory for development in risk-prone zones which allow e.g. the resilience of buildings to flooding and storms, potentially floating buildings, elevated traffic infrastructure (railway and roads) above flood levels, stormwater culverts able to absorb future increased stormwater volumes • Relocate vulnerable coastal infrastructure (such as power stations, sewage treatment plants, but also hospitals, police stations etc.) to safer locations. • Climate-educate communities and industries, e.g. on sustainable use of freshwater, the importance of stormwater drainage systems and their vulnerability to blockage • Creation of Early Warning Systems and safe Evacuation sites • Diversify coastal livelihoods to reduce dependence on potentially climate-threatened income sources.
Progress on policy, strategy and legislation	• Climate Change Bill, South Africa's National Assembly passed the Climate Change Bill in 2024, the first piece of legislation in the country specifically aimed at mitigating and addressing the effects of climate change. • Integrated Coastal Management Act (Act 24 of 2008). • National Climate Change Response Policy (NCCRP, or White Paper) 2011 • White Paper on Conservation and Sustainable Use of South Africa's Biodiversity (2023) • Spatial Planning and Land Use Management Act, No. 16 of 2013 (SPLUMA) • White Paper for Sustainable Coastal Development (Republic of South Africa, 2000)

Sector	Coast
	• National Climate Change Adaptation Strategy (NCCAS, 2019) • Climate Adaptation Response Plan for South Africa's Coastal Sector (draft version June 2024, final version expected Feb. 2025) • Western Cape Climate Change Response Strategy (2014)

Table 3.24: Adaptation actions and progress on key policy, strategy and legislation per sector: Marine Sector

Sector	Marine
Adaptation actions	• Enhancing monitoring and research to understand changes in fish populations and ecosystems. • Promoting sustainable fishing practices to reduce pressure on vulnerable species. • Protecting and restoring critical habitats to support fish populations. • Developing alternative livelihoods and diversifying income sources for fishing communities. • Strengthening policies and regulations to manage fisheries in the context of climate change and promote resilience in the sector.
Progress on policy, strategy and legislation	• **Marine Spatial Planning Framework (MSPF) 2021**: The MSPF aims to balance ecological, economic, and social objectives in the management of marine and coastal areas. It provides a structured approach to planning and managing marine resources, considering the impacts of climate change on marine ecosystems and human activities. • The framework supports the identification of areas for conservation, sustainable use, and economic development, including fisheries and aquaculture. • **Operation Phakisa - Oceans Economy**: This is a government initiative aimed at unlocking the economic potential of South Africa's oceans. It focuses on sectors such as marine transport, offshore oil and gas exploration, aquaculture, marine protection services, and ocean governance. The initiative includes measures to promote sustainable fishing practices, enhance marine conservation, and address climate change impacts on the marine economy. • **Climate Change Bill**: This will provide a comprehensive legal framework for climate change mitigation and adaptation in South Africa. It will establish mechanisms for integrating climate change considerations into sectoral policies, including those related to fisheries and marine resources.

Table 3.25: Adaptation actions and progress on key policy, strategy and legislation per sector: Mining

Sector	Mining
Adaptation actions	• Water Management - Implementing water-saving technologies and practices, such as recycling water used in mining processes, can help mitigate the effects of water scarcity. • Energy Efficiency and Renewable Energy - Upgrading equipment and optimizing processes to reduce energy consumption. Transitioning to renewable energy sources, such as solar and wind, to power mining operations can reduce carbon emissions and enhance energy security. • Infrastructure Resilience - Designing and constructing infrastructure to withstand extreme weather events, such as floods and heatwaves. • Diversifying Supply Chains - Developing robust and flexible supply chains that can adapt to disruptions caused by climate impacts. • Environmental and Ecosystem Management - Implementing measures to protect local biodiversity and rehabilitate mining sites to enhance. Strengthening efforts to control pollution and minimize environmental degradation from mining activities. • Risk Management and Monitoring - Conducting regular climate risk assessments to identify vulnerabilities and develop targeted adaptation strategies. Establishing monitoring systems to track climate impacts and effectiveness of adaptation measures. • Regulatory Compliance - Ensuring compliance with existing and emerging environmental regulations related to climate change. • Research and Innovation - Investing in research and development to explore innovative technologies and practices for climate adaptation.
Progress on policy, strategy and legislation	• **Carbon Tax Act 2019** - Imposes taxes on carbon emissions from mining operations, incentivizing the adoption of cleaner technologies and practices. • **Climate Change Bill** - Mining companies must assess climate risks and implement adaptation measures to protect operations and communities. • The Integrated Resource Plan (IRP) towards 2030 • One of South Africa’s key policies to reduce emissions and address the energy crisis is the Integrated Resource Plan (IRP) 2010–2030 updated in 2023 (DMRE, 2023). It sets targets for renewable energy capacity and aims to reduce dependency on coal.

Table 3.26: Adaptation actions and progress on key policy, strategy and legislation per sector: Transportation

Sector	Transportation
Adaptation actions	• Implementation of so-called "hard" infrastructure-related measures, for example building flood barriers or improving drainage, whilst operational resilience is amenable to "soft" approaches, such as scheduling of maintenance or transport services. SANRAL is actively working on incorporating climate resilience into road infrastructure projects. This includes improving drainage systems, reinforcing bridges, and using durable materials that can withstand extreme weather. Improving infrastructure design and maintenance. • Implementing regular inspections and maintenance to ensure infrastructure remains robust against climate impacts. E.g. maintaining gravel roads more frequently, upgrading gravel to tar, and building better tar roads. This would hasten the transition to climate resilience, while saving money and creating new employment. • Building new transport infrastructure with future climate risks in mind is crucial. This includes using heat-resistant materials for roads, constructing seawalls and levees for coastal protection, and improving drainage systems in urban areas to handle increased rainfall. • Climate resilient road design for example the use of modern modified bitumen binders or adjusting bitumen binder content in asphalt can maximize the suitability of road surfaces to changing weather and climate conditions. The use of waste plastic as a binder increases the flexibility and resistance to temperature variations and provides a sustainable re-use alternative for plastic waste. <u>Enhancing flood management and drainage systems</u>: • Upgrading stormwater drainage systems to handle increased precipitation and reduce flooding risks on roads. • Introducing green infrastructure like permeable pavements and roadside vegetation to absorb excess water and mitigate flooding. <u>Risk assessments and early warning systems</u> • Conducting regular risk assessments for transport infrastructure vulnerabilities to extreme weather events allows for proactive measures. • Implementing early warning systems can trigger preventative actions like closing roads before floods or securing loose objects on bridges before strong winds. <u>Integrated planning and policy</u> • Establishing zoning regulations that avoid construction in high-risk areas prone to flooding or erosion. • Integrating climate change adaptation into national and regional transport policies and strategies. • Investment in Public Transport • Investing in sustainable public transit systems that reduce dependency on private vehicles, thereby lowering emissions and enhancing resilience to climate impacts.
Progress on policy, strategy and legislation	• **Green Transport Strategy (2018 - 2050).** The Green Transport Strategy (GTS) of South Africa (2018-2050) serves as a roadmap for the Department of Transport (DoT) to contribute to a more sustainable and climate-friendly transport sector. • National Transport Master Plan (NATMAP) 2050

Sector	Transportation
	• NATMAP aims to create an integrated, efficient, and sustainable transport system by 2050. It includes provisions for adapting transport infrastructure to climate change impacts. • **National Land Transport Strategic Framework (2023 -2028).** This framework is a crucial document outlining South Africa's strategic vision for its land transport sector over the next five years.

Table 3.27: Adaptation actions and progress on key policy, strategy and legislation per sector:

Sector	Energy
Adaptation actions	Diversifying Energy Sources • Accelerate the development and integration of renewable energy sources such as wind, solar, and hydroelectric power. Programs like the Renewable Energy Independent Power Producer Procurement Program (REIPPPP) are pivotal in this effort. • Increase the use of natural gas as a transitional fuel to reduce reliance on coal and lower greenhouse gas emissions while providing more flexibility to the grid. Infrastructure resilience • Invest in modernizing and strengthening the existing energy infrastructure, including transmission and distribution networks, to withstand extreme weather events and other climate-related stresses. • Promote the development of decentralized energy systems, such as microgrids and distributed generation, to enhance local resilience and reduce the impact of large-scale disruptions. Climate-smart planning • Develop and adopt technologies for recycling and reusing water in power generation processes to mitigate the impact of water scarcity. • Incorporate climate change scenarios and projections into integrated resource planning to ensure long-term sustainability and resilience of the energy sector. Policy and regulatory frameworks • Develop and implement policies that support climate adaptation measures, such as incentives for renewable energy adoption, stringent efficiency standards, and regulations that encourage climate-resilient infrastructure development. • Foster collaboration between government, private sector, and civil society to develop and implement effective adaptation strategies. Research and innovation • Support research and development initiatives focused on innovative adaptation technologies and practices, such as advanced energy storage solutions and climate-resilient grid infrastructure. • Implement pilot projects to test and demonstrate the effectiveness of various adaptation strategies, which can then be scaled up based on successful outcomes. Capacity building and education • Develop training programs for energy sector professionals to enhance their understanding of climate change impacts and adaptation strategies. • Raise awareness among consumers and stakeholders about the importance of climate adaptation and the role they can play in supporting sustainable energy practices.

Sector	Energy
Progress on policy, strategy and legislation	• The Integrated Resource Plan (IRP) towards 2030. One of South Africa's key policies to reduce emissions and address the energy crisis is the Integrated Resource Plan (IRP) 2010–2030 updated in 2023 (DMRE, 2023). It sets targets for renewable energy capacity and aims to reduce dependency on coal. • Just Energy Transition Implementation Plan (JET IP). The JET IP is set for a five-year period (2023-2027) and sets out several interventions and investments which are needed in South Africa for the country to transition into a low carbon and climate resilient economy. • Renewable Energy Independent Power Producer Procurement Program (REIPPPP) • The REIPPPP was introduced to implement the objectives of the Integrated Resource Plan. It facilitates the procurement of renewable energy from private producers to diversify the energy mix. It aims to increase the share of renewables in the energy sector, create jobs, and promote economic transformation. • South African Renewable Energy Master Plan (SAREM) • Aims to create a comprehensive plan for the growth and development of the renewable energy sector. It focuses on scaling up renewable energy capacity, promoting local manufacturing, and enhancing job creation.

3.4.2 Provincial climate change responses

The NCCRP required each of South Africa's nine provinces to develop a climate change response strategy. The strategy is expected to reflect the province's climate risks and impacts and to integrate NCCRP principles. Provincial climate-change-response policies and strategies are aligned with national policies and framed within the NCCRP and guided by the NDP. Because the NCCRP makes integrated planning a national priority, climate change considerations and responses are a part of all relevant provincial and local planning regimes. The NCCAS recognises that provincial and local governments would have different resources available to implement national priorities and recommends that the adaptation priorities should be interpreted within the spatial area of the relevant authority, with the minimum information as stipulated for sectors, being applied as appropriate. Strategic intervention 4 in the NCCAS is to 'Facilitate mainstreaming of adaptation responses into sectoral planning and implementation' with key outcomes for the intervention including:

- Provincial strategies and associated implementation plans should be reviewed and updated every five years.
- Integrate climate change adaptation into Provincial Growth and Development

Strategies. This will involve each province ensuring that climate change projects and programmes are reflected in their strategic Provincial Growth and Development Strategies.

The Climate Change Act, 2024 mandates Provinces to undertake climate change needs and response assessments for the province and develop the associated implementation plan which its effective implementation should be coordinated through the Provincial Climate Change Forum in the form of annual reporting. In 2015, a Situational Analysis and Needs Assessment (SANAs) was undertaken to determine the preparedness to implement the National Climate Change Response Policy (NCCRP) Section 10.2.6. The needs, gaps identified and recommendations of the 2015 SANAs informed the development of Provincial Climate Support Programme, and the implementation of which resulted in the development and review of Climate Change Response Strategies for all nine (9) Provinces, establishment of Climate Change Fora, establishment and secondment of Climate Change units and officials for climate change related functions as well as catalysing and funding project implementation. The SANA's has since garnered support from MinTech and MinMEc with a standing agenda item on continuous progress update (DFFE, 2024).

Through the Provincial Climate Support Programme, provinces and municipalities were supported to undertake climate change risk and vulnerability assessments and develop adaptation strategies. To date, all 9 South African Provinces (Free State, Gauteng, KwaZulu-Natal, Limpopo, Mpumalanga, the Northern Cape, Northwest, Northern, Eastern Cape and the Western Cape) have reviewed or are in the process of reviewing the provincial climate change strategies, and there have been efforts from the provinces to implement the adaptation options as prioritised in the strategies. Further to that, all provinces have established a reflective learning forums and committees which facilitates peer-to-peer learning and sharing of information on climate change adaptation amongst different stakeholders.

A prioritisation criterion was developed that sought to rank the Sectors as per the Priorities needs. This informed further support through the development of Technical and Financial Project Proposals for all Provinces. The DFFE supported the review of five (5) Provincial Climate Change Adaptation Strategies to update the Risk and Vulnerability Assessment and compile a Green House Gas Inventory in the 2021/22 Financial year. Two more Provinces followed on with the review process bringing all nine (9) Provinces into alignment (Gauteng and Westen Cape Province included). The review process includes the Sectoral Polices and plans in place vulnerable to the impacts of climate change such as IDPs, Disasters Management Plans etc. to achieve a 100% coverage of climate change considerations in sectoral operational plans (DFFE, 2024).

Climate change interventions that are being implemented by Provinces in all identified key sectors include (DFFE, 2024):

- Climate Change Response Strategies (Draft climate change education and awareness plan 2023/2024 developed /Developed and implemented Wildfire Management Framework (WFMF).
- Climate Change strategy exist for all provinces with Free State still in a process of reviewing and KwaZulu-Natal Climate Change Strategy and Implementation Plan adopted by the Executive on 04 October 2023.
- Partnerships with other institutions.
- Climate Change Champions at Provincial and District level.
- Climate change projects under implementation.
- Collaborations with Sector Departments on Implementation (Economic Cluster).
- Emissions Pathway Analysis, Adaptation Pathway for example in Western Cape
- Improvement of basic service challenges and issues within the local government, for instance waste collection and management.

3.4.3 Integration of gender perspectives and indigenous, traditional and local knowledge into adaptation

Climate change represents one of the most urgent and multifaceted challenges of our time, with profound implications for every sector of society. However, the impacts of climate change are not uniformly distributed; they are deeply interwoven with preexisting social, economic, and cultural inequalities. Among these intersecting axes of disparity, gender emerges as a crucial factor in shaping the experiences and vulnerabilities of individuals in the context of climate change. Women, in particular, bear a disproportionate burden due to their roles as primary caregivers and household managers, which often restrict their mobility and access to critical resources. These gender-specific vulnerabilities are further compounded by economic disadvantages, such as limited access to land, financial resources, and decision-making power.

Acknowledging these inequities, gender-responsive approaches to climate change have become indispensable. Such approaches involve the systematic integration of gender perspectives into all stages of climate policy and program development. The goal is to ensure that climate actions do not perpetuate or intensify gender inequalities but rather promote gender equality and empower women. This requires the cultivation of conditions where both women and men can equally participate in and benefit from climate resilience initiatives.

3.4.3.1 Gender-climate change mainstreaming in South Africa

In South Africa, climate change exerts differentiated impacts on women, men and non-gender conforming individuals, with women bearing a greater burden due to gendered household norms and patriarchal social structures. Despite a comprehensive legal and policy framework aimed at promoting gender equality, gender mainstreaming in climate change policies and legislation remains inadequate (Smout, 2020). Key findings indicate that South Africa’s response to climate change lacks sufficient gender-responsiveness. For example, higher unemployment rates among women, lower economic participation, and higher poverty rates underscore the economic disparities that heighten women’s vulnerability to climate change. Additionally, higher school dropout rates among girls and unequal access to land and property ownership further hinder women’s capacity to adapt to the consequences of climate change (Smout, 2020). The gendered effects of climate change in South Africa include increased caregiving responsibilities for women during climate-related disasters, which restrict their ability to engage in income-generating activities and decision-making processes. Women also face heightened risks of gender-based violence, unequal access to resources such as land and water, and disproportionate health impacts linked to their domestic roles (Smout, 2020). Overcoming these challenges requires ambitious climate actions aligned with the Paris Agreement and a stronger gender-responsive approach (Smout, 2020).

Gender mainstreaming is a strategy designed to achieve gender equality by integrating gender perspectives and considerations into all policies, programs, and activities. This approach ensures that both women and men can equally participate in and benefit from development processes, including climate change adaptation and mitigation. Mainstreaming climate change into national agendas is crucial for ensuring comprehensive and coordinated responses to the multifaceted impacts of climate change. This process involves integrating climate considerations into all aspects of policy-making, planning, and implementation across various sectors. In South Africa, gender mainstreaming is a key component of these efforts, recognizing that climate change impacts men and women differently and that gender-responsive strategies are essential for effective and equitable climate adaptation and mitigation. South Africa's approach to gender mainstreaming, particularly in the context of climate change, is detailed in various strategic documents and programmes, such as the National Strategy towards Gender Mainstreaming in the Environment Sector and the draft Gender Action Plan (GAP), the National Climate Change Adaptation Strategy (NCCAS), and Capacity Building Initiative for Transparency (CBIT) Programmes.

The National Strategy towards Gender Mainstreaming in the Environment Sector (2016-2021) provides strategic guidance for embedding gender considerations into environmental policies and actions. It outlines the principles, approaches, and actions necessary for effective gender-mainstreaming within the Environment sector (DFFE, 2016). The aim of the strategy is to promote a gender sensitive management approach in the environment sector; ensure that initiatives in the sector are aimed to support the creation of policies that support gender mainstreaming; and ensure gender analysis and mainstreaming during the development of new projects and including gender perspective into the whole project cycle management.

The draft Gender Action Plan (GAP) (DFFE, 2022) is a critical component of South Africa's strategy for integrating gender considerations into climate change policies and actions. The GAP draws on previous work and stakeholder consultations which formed part of the UNDP Climate Promise Programme in SA, on behalf of DFFE, to propose a work plan for gender climate mainstreaming that affects transformative change across all NDC sectors in South Africa. The GAP also builds on the outcomes of the National Dialogue for Gender-Climate Mainstreaming of July 2022 in which participants were universal in their call for action-oriented gender-climate mainstreaming. Recognizing the differentiated impacts of climate change on various genders, the GAP aims to ensure that climate resilience efforts are inclusive and equitable. The plan outlines six strategic actions designed to mainstream gender into all aspects of climate adaptation, thus fostering a comprehensive and gender-responsive climate policy framework, viz:

1. Revise and clarify institutional arrangements for gender-climate mainstreaming
2. Formalise relationships for sectoral gender mainstreaming across South Africa's National Gender Machinery
3. Strengthen sectoral gender-climate policies
4. Establish robust, participatory Monitoring and Evaluation (M&E) frameworks for gender-climate mainstreaming
5. Align funding streams for gender-climate mainstreaming
6. Implement a gender awareness raising and capacity building programme.

These strategic actions are scheduled to be rolled out over five years, following the legal review period for NDCs as established under the 2015 Paris Agreement.

The National Climate Change Adaptation Strategy (NCCAS) of South Africa also underscores the critical importance of gender mainstreaming as an integral element of building climate resilience. By incorporating gender considerations into climate adaptation policies and practices, the NCCAS ensures that the unique vulnerabilities and strengths of different genders are recognized and addressed. This approach acknowledges that gender equality is essential for achieving effective and sustainable climate adaptation outcomes.

The integration of adaptation measures into various sectoral policies is a crucial aspect of South Africa's National Climate Change Adaptation Strategy (NCCAS). By ensuring that gender considerations are mainstreamed into climate change actions across sectors such as agriculture, water, health, and human settlements, the NCCAS promotes a holistic approach to building climate resilience. Each sector is tasked with developing dedicated gender policies that address unique challenges and opportunities within their specific contexts, ensuring that adaptation strategies are both effective and equitable.

The NCCAS also highlights the importance of capacity building and raising awareness about gender and climate change which involves providing education and training tailored to different stakeholders, from government officials to local community members. Training programs on gender-climate mainstreaming are designed to equip participants with the skills necessary to integrate gender considerations into climate adaptation planning and implementation.

In terms of policy integration and co-ordination, integrating gender considerations into national policies and strategies is a fundamental aspect of the NCCAS. The strategy calls for the revision and development of sectoral policies that explicitly address gender issues. The NCCAS, as well as the draft GAP, emphasises the need for robust monitoring and evaluation frameworks to track progress in gender mainstreaming. These frameworks include gender-sensitive indicators and targets, ensuring that adaptation actions are assessed for their impact on gender equality. Regular assessments and feedback loops help refine strategies and improve the integration of gender considerations over time. The NCCAS also calls for the identification and mobilization of funding sources that prioritize gender equality and women's empowerment in climate change actions. Engaging both public and private sectors to provide adequate financial support for gender-climate mainstreaming activities is essential. This includes advocating for dedicated funding streams and financial mechanisms that support women's participation in climate adaptation projects (DEA, 2019).

The Capacity Building Initiative for Transparency (CBIT) is designed to enhance the capacity of developing countries to meet transparency requirements under the Paris Agreement. In South Africa, CBIT programmes include an adaptation component that focuses on building institutional capacity for climate adaptation planning and implementation. These programmes emphasize the importance of gender mainstreaming by providing training and resources to government officials and stakeholders on integrating gender considerations into climate policies and actions.

3.4.3.2 Indigenous Knowledge Systems

Indigenous Knowledge Systems (IKS) play a critical role in climate change adaptation in South Africa. These systems, rooted in the local knowledge and practices of indigenous communities, offer valuable insights and strategies for coping with the impacts of climate change. Indigenous knowledge encompasses a holistic understanding of the environment, sustainable resource management, and adaptive practices that have been honed over generations.

3.4.3.2.1 Holistic environmental understanding

Indigenous knowledge systems are characterized by a profound understanding of the local environment and its interconnected systems. Indigenous communities have long relied on observational skills and traditional ecological knowledge to predict weather patterns, understand climatic changes, and adapt agricultural practices accordingly. This knowledge is essential for developing localized climate adaptation strategies that are culturally appropriate and sustainable. For instance, indigenous communities in South Africa have utilized their understanding of local flora and fauna to manage resources sustainably, ensuring resilience in the face of climatic variations (Smout, 2020).

3.4.3.2.2 Sustainable resource management

One of the key strengths of indigenous knowledge systems is their emphasis on sustainable resource management. Indigenous practices often involve the conservation of biodiversity, soil fertility maintenance, and water management techniques that are crucial for climate resilience. For example, traditional agricultural practices such as crop rotation, intercropping, and the use of organic fertilizers help maintain soil health and reduce vulnerability to climate-induced stresses. These practices not only enhance agricultural productivity but also contribute to the long-term sustainability of the environment (Modise et al., 2024).

3.4.3.2.3 Adaptive practices and resilience

Indigenous communities have developed a range of adaptive practices that enhance their resilience to climate change. These practices include the selection of drought-resistant crops, the construction of flood-resistant housing, and the implementation of traditional water conservation methods such as rainwater harvesting and the construction of small dams. By integrating these practices into broader climate adaptation strategies, policymakers can leverage indigenous knowledge to enhance community resilience and reduce vulnerability to climate impacts (DEA, 2019).

3.4.3.2.4 Knowledge transmission and cultural preservation

The transmission of indigenous knowledge is often facilitated through cultural practices, oral traditions, and community gatherings. This knowledge transfer is crucial for maintaining the continuity of adaptive practices and ensuring that future generations are equipped to manage climate risks. Engaging indigenous communities in the documentation and dissemination of their knowledge can strengthen climate adaptation efforts and promote the preservation of cultural heritage. This approach not only empowers indigenous communities but also enriches the broader knowledge base available for climate adaptation (Smout, 2020).

3.4.3.3 Challenges and integration

Despite the value of indigenous knowledge systems, there are challenges to their integration into formal climate adaptation policies. These challenges include the marginalization of indigenous communities, the undervaluation of traditional knowledge, and the lack of mechanisms for incorporating indigenous practices into mainstream policy frameworks. To address these challenges, it is essential to create inclusive platforms for dialogue, ensure the participation of indigenous communities in decision-making processes, and develop policies that recognize and support the contributions of indigenous knowledge to climate adaptation (Modise et al., 2024).

3.5 Progress on implementation of adaptation

3.5.1 The National Government Programme of Work

3.5.1.1 DFFE Adaptive Capacity Facility (DFFE-ACF)

The Government of Flanders and the Government of South Africa have had a long-standing relationship, which has evolved based on international developments, cooperation, and past experiences. The Country Strategy Paper (CSP) III has been developed through a joint consultation process between the two governments and is being implemented from 2017 to 2021, with a focus on climate change adaptation and the green economy. The primary objective of the CSP III is to address the triple challenge of inequality, poverty, and unemployment. Over five years, 25 million Euros have been invested as part of the CSP III, to tackle the lack of effective climate change implementation at the local level in South Africa. The DFFE has partnered with the Government of Flanders to develop the DFFE Adaptive Capacity Facility (DFFE-ACF or ACF) under the CSP III (2017-2021). The DFFE Adaptive Capacity Facility is a project funded by the Adaptation Fund to help vulnerable communities in South Africa cope with the impacts of climate change (DFFE, 2023). It aims to build climate resilience and adaptive capacity, integrate climate change adaptation into development objectives, improve understanding of climate change impacts and responses, and ensure resources and systems for implementation. The project is implemented by DFFE in three district municipalities: Amathole, Garden Route and uMzinyathi (DFFE, 2023).

3.5.1.2 Civil Society Implemented Climate Change Adaptation Projects

A total of 14 projects have been approved for implementation in South Africa from 2019 to-date by the Flanders Government. The projects cover various sectors including:

- Climate-smart enterprises providing market-based solutions which help to enhance the adaptive capacities of the South African economy.
- Building resilience and reducing the vulnerability of smallholder farmers.
- Enabling community-based adaptation in the Mkhuze River Ecosystem, KZN.

- Building climate resilience of coastal communities, ecosystems and small-scale fishers through implementing community and ecosystem-based adaptation activities and diversifying livelihoods.

The few projects mentioned above are part of the 14 that have been funded or approved for funding. The government of Flanders has further funded other climate change adaptation projects that have already been implemented or are under implementation.

3.5.1.3 Cities Resilience Programme led by the National Treasury and DFFE

The overarching objective of the National Treasury Cities Support Programme (NTCSP) under which the Cities Resilient Programme is run is to improve inclusive economic growth in cities in response to pressing development challenges. It is a multi-year demand-driven umbrella programme which will contribute to the creation of productive, well-governed, inclusive, and sustainable cities. The direct beneficiaries of the CSP support are South African national departments, provincial departments, and metro stakeholders. The indirect beneficiaries are the citizens of the eight metros, namely, citizens of eThekwini, Buffalo City, City of Johannesburg, City of Tshwane, Nelson Mandela Bay, Ekurhuleni, City of Cape Town, and Mangaung. The CSP delivers support through six components, including:

(1) governance,
(2) fiscal and financial,
(3) climate & sustainability,
(4) public transport,
(5) human settlements, and)
(6) economic development.

All these projects are intended to reduce the community's vulnerability to climate variability resulting from weather shocks; and reduce vulnerability to climate risks in urban areas, the following projects:

- Improved disaster management - Cape Town: Flood Management Programme
- Climate resilient planning - Ekurhuleni: Kaalspruit Wetlands Rehabilitation, Tshwane: Hennops River Rehabilitation
- Climate resilient capital investments - Mangaung: Bloemspruit Airport Node Resilient Development
- Water resilience - Cape Town: Liveable Urban Waterway Programme
- Solid waste transitions - eThekwini: Shongweni Integrated Waste Management Facility
- Sustainable municipal energy - Buffalo City: Energy Storage Facilities, Johannesburg: Land Rehabilitation and Renewable Energy

In addition, priorities are also given to the coastal cities, through the following adaptation options:

- Green Infrastructure – to improve the effective capturing and filtering of rain and stormwater.
- Bioswales: to be used as an alternative to concrete gutters and storm sewers. Bioswales use vegetated low-lying areas lined with plant materials and specialised soil mixes to treat, absorb, and convey stormwater runoff. Bioswales also have the potential to create habitats for birds, butterflies, and local wildlife as well as reduce the risk of curd flooding.
- Early Warning Systems: Education and training on what should be done once a warning is issued.
- Wetlands encroachment: Strict enforcement of wetland encroachment, and comprehensive education and awareness of the risk's inhabitants face in the area.
- Rain Gardens - Shallow, densely vegetated ground depressions, with a variety of trees, shrubs, and grasses to facilitate ground infiltration and cleaning of stormwater. Areas can also be used as recreational areas for citizens.

- Stormwater Harvesting: These are shallow, densely vegetated ground depressions, with a variety of trees, shrubs and grasses used to increase the capacity of sewer and stormwater systems, reduce the damage from pluvial floods and improve water security.
- Reduce Heat Trapping: Cool roofs reflect heat energy, reducing the heat-trapping effect in urban areas. Cool or Green Pavements (Permeable pavements) allow for the infiltration of water into the ground, reducing runoff.
- Rainwater Harvesting: to reduce surface runoff.

3.5.1.4 The South African National Biodiversity Institute (SANBI) Programme of Work

a. Community-Based Adaptation Small Grants Facility

The 'Taking Adaptation to the Ground: A Small Grants Facility for Enabling Local Level Responses to Climate Change' project, was implemented in the Namakwa and Mopani district municipalities (SANBI, 2022). The overall objective of the Small Grants Facility project was to ensure that vulnerable, rural communities in the project target areas have increased resilience to the expected impacts of climate variability and change through the integration of climate adaptation response strategies into local practices (SANBI, 2022). The project also piloted and developed an understanding of small grant mechanism development and implementation in the context of climate finance, to scale up and replicate this model.

Through the executing entity, the project contracted 12 small grant recipients to implement small grant projects that built the climate resilience of vulnerable community members against the impacts of climate change. The projects directly benefitted close to 2 000 community members who live in areas vulnerable to the effects of climate change, which greatly exceeds the targeted number of direct beneficiaries (the original target was 600 direct beneficiaries). (SANBI, 2022). Under the guidance of The Facilitating Agencies for each target district, Conservation South Africa in the Namakwa district and CHoiCe Trust in the Mopani District, the project supported the small grant recipients in the implementation of their approved projects. The project objectives included capacity building premised on needs identified throughout the project (SANBI, 2022). In its final year, ending December 2021, SANBI consolidated the lessons learned through the project through the development of a set of communication products that included the finalisation of a set of eight case studies, a policy brief and the development of a blueprint for scaling up locally-led adaptation in South Africa and beyond (SANBI, 2022).

b. uMngeni Resilience Project (Ecosystem Based Adaptation and Early Warning)

In its capacity as South Africa's National Implementing Entity of the Adaptation Fund, SANBI has continued to oversee the implementation of the USD 7.5 million Building Resilience in the Greater uMngeni Catchment Project. The 'Building Resilience in the Greater uMngeni Catchment' project is being implemented by the uMgungundlovu District Municipality in collaboration with the University of KwaZulu-Natal (SANBI, 2022). During 2022/2023, the project entered its final stages of implementation (SANBI, 2023). The overall objective of the project is to reduce the vulnerability of communities and small-scale farmers in the District Municipality to the adverse impacts of climate change. This is to be accomplished through implementing a suite of corresponding gender-sensitive project interventions, focusing on:

- Early warning systems
- Ecological and community infrastructure strengthening
- Small-scale climate-resilient agriculture.
- Knowledge management (SANBI, 2022).

Through the Early Warning System component, which is led by UKZN in partnership with the South African Weather Service and KZN-Cooperative Governance and Traditional Affairs, several individual Early Warning Systems have been developed. These include the Flood, Fire, Agrometeorological, Rangeland and Lightning Early Warnings Systems. These will increase the resilience of the ~100,000 community members in the catchment areas covered by the systems. This far exceeds the high-level target of the project, which is that 25,000 vulnerable community members are more resilient to the impacts of climate change because of the uMngeni Resilience

Project. The DFFE and SAWS have developed a project that will scale up this work with support from the Government of Flanders.

Under the Built Environment component, over 250 rural homesteads were strengthened to better withstand the impacts of climate change, five pedestrian bridges were built, and 2 km of stormwater drains were constructed to better withstand the impacts of floods that are occurring more frequently and intensely than previously. Due to various challenges, the target for houses and stormwater drains was not fully met.

Through the Ecological Infrastructure work over 200 ha of degraded grassland has been restored and is under improved rangeland management practices (see figure 36). The identified wetlands were rehabilitated, with successful removal of over 2,500 ha of alien invasive vegetation from the project target areas (compared to the intended target of 150 ha). Additionally, more than 100 km of firebreaks were established.

Through the Knowledge Management and Capacity Building part of the project, over 1,300 community members have been trained through various climate change-related training courses, including accredited courses. This has resulted in over 65 National Qualifications Framework (NQF) certificates being awarded to project beneficiaries. Climate change awareness raising has been done through community and school engagement programmes, and several reflection workshops were held. A set of brochures on the different components and learnings emanating from the project and a set of policy briefs and recommendations were developed and will be widely shared. A highly successful uMngeni Resilience Project Climate Change Indaba was held, attended by representatives of communities, civil society organisations, government officials and academics from various institutions across the country. The Indaba provided an opportunity to visit the project implementation sites, reflect on the achievements of this national flagship adaptation project, share perspectives from the project and related initiatives, and discuss policy recommendations to facilitate scaling solutions.

c. Green Climate Fund Readiness Support

SANBI closed out its USD 380 000 Readiness Support Grant from the GCF The grant was used to develop a set of processes and tools to facilitate improved management of SANBI's anticipated GCF portfolio of projects, to develop initial concept note proposals for submission to the GCF, and to engage the private sector towards developing a programme of work for private sector involvement adaptation projects in South Africa (SANBI, 2022).

Unlocking Climate Finance for Climate Change Adaptation

SANBI has received core support from the Government of Flanders to develop a funded portfolio of GCF projects. The EUR 2 646 832 (approximately R48 million) project, approved in 2020, runs until November 2024 ((SANBI, 2022).

This project aims to deliver:

- At least four full funding proposals (with values of at least USD 10 million in GCF investments each) being submitted to and being supported by the GCF
- Residual capacity to lead this work being built within SANBI and other South African institutions.
- The mobilisation of a science-based technical support network.
- A series of knowledge products that track this investment and contribute to a narrative that makes the case for sustained institutional investments in developing country direct access entities

SANBI will also show how investments in climate change adaptation are supporting the Just Transition to a climate-resilient society. The Government of Flanders's support is proving to be critical in improving South Africa's ability to reinforce the institutional and policy environment for climate change adaptation and will also contribute to reducing the vulnerability of target communities to the adverse impacts of climate change. Progress in the GCF project pipeline has resulted in one project under full proposal development, a second project's concept note which was endorsed by the GCF, and a third project concept note. This was possible with support from the Government of Flanders (SANBI, 2022).

3.6 Monitoring and evaluation of adaptation actions and processes

3.6.1 Approaches and systems for monitoring and evaluation adaptation actions

South Africa's approach to monitoring and evaluating climate change adaptation is multi-faceted, involving national, provincial, and local governments, research institutions, and the public. South Africa's legislative framework supports the monitoring and evaluation of climate adaptation through the newly-approved National Climate Change Act, the National Climate Change Response Policy (NCCRP) (2011) and the National Climate Change Adaptation Strategy (NCCAS) (2019). The Climate Change Bill is expected to significantly enhance the monitoring and evaluation (M&E) of adaptation to climate change. This legislation aims to provide a legal basis for climate change response actions, including the establishment of a robust monitoring and evaluation system. South Africa's National Adaptation Strategy (NAS) outlines the country's approach to adapt to the impacts of climate change. It sets out strategic priorities and actions across various sectors and levels of government. The NAS includes mechanisms for monitoring and reporting on progress through specific indicators and targets that are established to measure progress in implementing adaptation actions. It also requires the preparation of periodic reports to provide updates on the implementation of the NAS and the effectiveness of adaptation measures.

Adaptation monitoring and evaluation are conducted at the provincial and local levels. Provincial governments and municipalities develop their own climate change adaptation plans and frameworks, which align with the national strategy. These plans include local adaptation plans outlining specific adaptation actions tailored to local contexts and vulnerabilities. It also focusses on community-based monitoring by involving local communities in monitoring and evaluating adaptation actions to ensure they are effective and responsive to local needs.

South Africa also collaborates with various research institutions, universities, and international organizations to enhance its monitoring and evaluation capabilities. This includes research initiatives that focus on understanding climate impacts and developing adaptation solutions. South Africa collaborates with the Initiative for Climate Action Transparency (ICAT), a multi-stakeholder partnership, to improve the transparency and monitoring of its climate actions. ICAT focuses on developing robust methodologies for data collection, reporting, and verification to enhance the credibility of South Africa's climate efforts. ICAT’s support in South Africa has focused on enhancing monitoring and evaluation of adaptation responses in the areas of disaster risk reduction and early warning. ICAT has supported South Africa to strengthen the capacity to plan, implement, monitor, and evaluate effective and efficient adaptation actions. The first ICAT project, implemented together with CSIR, focused on establishing an M&E framework for disaster risk reduction actions and included the development for tools for M&E and indicators and building capacity of the key identified stakeholders. As a result, a (i) Multi-hazard Early Warning System (MH-EWS) M&E Framework was developed for South Africa and later followed by the elaboration of a (ii) draft framework for the M&E of impacts of climate- and weather-related disasters.

Public involvement is a crucial aspect of monitoring and evaluating climate adaptation. South Africa emphasizes regular consultations and workshops with stakeholders, including civil society, the private sector, and vulnerable communities, to gather input and feedback on adaptation efforts.

3.6.1.1 The National Climate Change Response Monitoring and Evaluation Framework

South Africa's National Climate Change Monitoring and Evaluation System Framework (NCCMR&E Framework) is a crucial tool for understanding the country's progress in addressing climate change. The framework aims to establish a systematic approach to monitoring and evaluating (M&E) South Africa's efforts to mitigate climate change (reducing greenhouse gas emissions) and adapt to impacts.

By tracking progress, the framework allows for informed decision-making, improved policy effectiveness, and greater transparency and accountability. South Africa's monitoring and evaluation of adaptation efforts to climate change are integral to ensuring accountability, transparency, and effectiveness in addressing the impacts of climate change. South Africa employs various mechanisms to monitor and evaluate adaptation efforts to climate change, ensuring that strategies are effective, responsive, and aligned with national priorities. One key mechanism is the National Climate Change Monitoring and Evaluation (M&E) System, established to track progress in implementing the country's National Climate Change Response Policy Framework and its associated plans and programs.

The National Climate Change M&E System is anchored in South Africa's National Climate Change Response Policy (NCCRP) and the National Development Plan (NDP). Transparency and reporting of progress on climate change response, enabled by the National Climate Change Monitoring and Evaluation (M&E) System/framework, are key to the effective implementation of the National Development Plan (NDP), 2030, National Climate Change Response Policy (NCCRP), National Climate Change Adaptation Strategy (NCCAS), Climate Change Bill, National Emissions Trajectory, Low Emissions Development Strategy (LEDS) and other guiding policies. The M&E system utilizes a range of indicators to assess the effectiveness and impact of adaptation actions across sectors, including agriculture, water, health, and infrastructure.

Its primary objectives are to:

- Monitor greenhouse gas (GHG) emissions and removals.
- Evaluate the effectiveness of climate change mitigation and adaptation measures.
- Inform policy-making and strategic planning.
- Ensure transparency and accountability in climate action.
- Facilitate reporting to international bodies, such as the United Nations Framework Convention on Climate Change (UNFCCC).

3.6.1.2 National Climate Change Information System (NCCIS)

The NCCIS (also referred to as the National Monitoring and Evaluation (M&E) system), was launched in August 2019 (see the NCCIS components in Figure 3.13). It is a web-based platform that provides access to information required for monitoring and evaluating the country's progress in accomplishing global goals, commitments, and targets, such as the National Development Plan (NDP) and Nationally Determined Contributions (NDCs). In addition, the NCCIS assesses climate change drivers, events, and their relationship with national objectives, targets, and strategies for climate change adaptation and mitigation. NCCIS is part of the national effort to monitor South Africa's transition by providing decision-support tools that inform policy and decision-making (DEA, 2020). It assesses the actions taken by stakeholders in this regard (DEA, 2020). NCCIS offers a range of decision support tools for policy and national decision-makers, including parliament and cabinet. Through the M&E system, South Africa's position is presented in various negotiation forums, such as the UNFCCC Conference of Parties (DFFE, 2022).

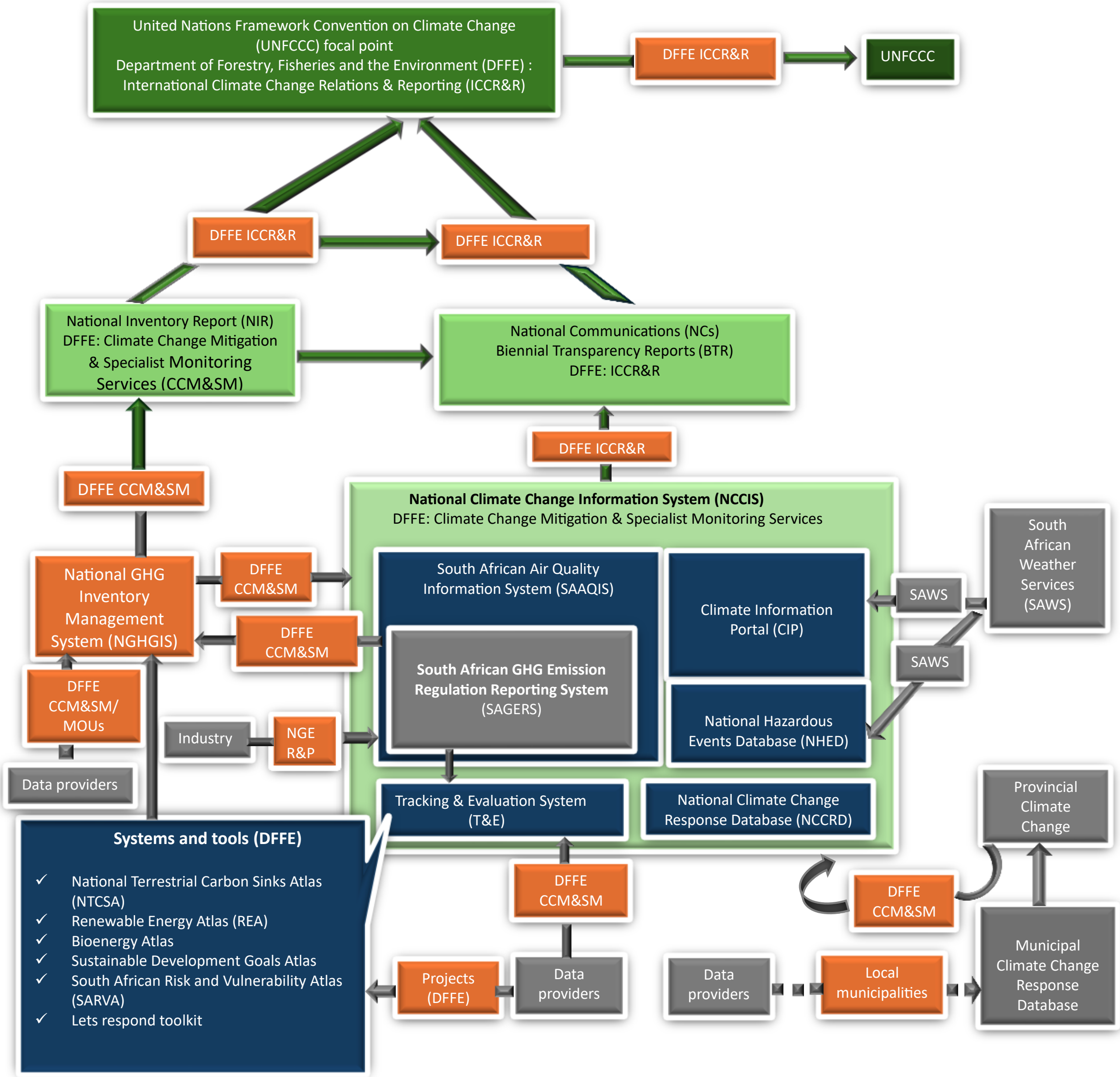

Figure 3.13 Structure of the National Climate Change Information System (NCCIS)

The NCCIS (figure 3.12) is composed of the following modules or subsystems to facilitate access to data and information on tracking South Africa's transition to a lower carbon and climate-resilient society:

- National climate change response database (NCCRD): a portal for capturing and reporting climate change projects and their details. The NCCRD functions as a central repository that consolidates information on climate change mitigation and adaptation activities across various sectors, including energy, agriculture, water, health, and transportation. The database captures details about the nature, scope, and impact of different projects, ensuring that all climate actions in South Africa are documented and easily accessible. The database is designed to promote transparency by allowing stakeholders, including the public, researchers, and international partners, to access information about climate projects. This open-access model enhances accountability, making it easier for various stakeholders to monitor the government's progress in addressing climate change.
- Climate information portal: It provides access to climate projections, historical climate data, risk assessments, and other crucial information that can be used for planning and decision-making. The portal covers diverse climate variables such as temperature, rainfall, and extreme weather events. The user-friendly interface allows non-experts to interact with climate data through maps, graphs, and charts that simplify complex climate information. The South African Weather Services as well as research institutions such as the CSIR play a key role in providing the climate data.
- Tracking and evaluation system: This component comprises of different systems and tools that track adaptation initiatives. It includes decision support systems and tools such as the South African Risk and Vulnerability Atlas, Bioenergy Atlas, Let's Respond Toolkit and National Terrestrial Carbon Sinks Atlas.
- The Greenhouse Gas (GHG) Inventory System: This system is responsible for

tracking and reporting South Africa's greenhouse gas emissions across various sectors such as energy, agriculture, waste, and industry. This component plays a critical role in the country's efforts to meet its emission reduction targets under the Paris Agreement.

- National Desired Adaptation Outcomes: designed as a monitoring and evaluation framework for climate change resilience through progress towards a series of adaptation goals.
- Services, tools, static content, documentation including reports, policies and guidelines, and other digital objects developed by external partners and stakeholders.
- Standardised vocabularies serve as a common frame of reference for climate change reporting and monitoring.
- Search and discovery capabilities (DFFE, 2022).

The NCCIS aggregates data from various sources, including government agencies, research institutions, and international bodies. This integrated approach ensures a holistic view of climate impacts and adaptation measures across different sectors and regions. The system includes specific indicators for monitoring adaptation progress, such as changes in climate resilience, vulnerability assessments, and the effectiveness of adaptation interventions. These indicators are critical for evaluating the impact of adaptation strategies over time. The NCCIS provides a baseline for assessing current climate vulnerabilities and the status of adaptation initiatives. This baseline is essential for measuring progress and identifying areas that require further attention. The system allows for regular updates and real-time monitoring of adaptation activities. This continuous tracking helps in identifying trends, emerging issues, and the effectiveness of ongoing projects. Advanced analytical tools within the NCCIS enable detailed impact analysis of adaptation measures. This analysis helps to determine which strategies are most effective in reducing vulnerability and enhancing resilience.

By providing accurate and up-to-date information, the NCCIS supports the formulation of evidence-based policies. Policymakers can use this data to design and implement more effective adaptation strategies that are tailored to specific regional and sectoral needs. The NCCIS aids in strategic planning by highlighting priority areas for adaptation investment. It helps in allocating resources efficiently and ensuring that adaptation efforts are aligned with national and local development goals.

The NCCIS facilitates transparent reporting on adaptation progress to national and international stakeholders. It supports South Africa's commitments under the United Nations Framework Convention on Climate Change (UNFCCC) by providing accurate and comprehensive reports on adaptation actions and outcomes. The system promotes accountability by engaging a wide range of stakeholders, including government agencies, NGOs, and local communities. This engagement ensures that diverse perspectives are considered and that adaptation measures are inclusive and equitable.

The NCCIS provides training and technical support to enhance the capacity of institutions and individuals involved in adaptation efforts. This capacity building is crucial for maintaining the quality and consistency of data and for effectively implementing adaptation strategies. The platform serves as a repository of best practices, case studies, and lessons learned from various adaptation projects. This knowledge dissemination helps in scaling up successful interventions and avoiding common pitfalls.

The NCCIS incorporates advanced technologies such as Geographic Information Systems (GIS), remote sensing, and data analytics. These tools enable precise mapping and assessment of climate risks and adaptation needs.

3.6.1.3 Improvements and expansion of the NCCIS

The NCCIS institutional arrangements have been designed to facilitate national sector departments and provinces’ ownership and buy-in. This involves creating subsystems that are specific to each sector and province, which are then integrated into the NCCIS. The first provincial M&E and climate information system was piloted in Mpumalanga province in 2021, while the Gauteng Province as well as the Free State Provincial Climate Information Systems are under development. These provincial sub-systems are customized to address the climate change needs of the province and include downscaled climate, risk and vulnerability information, and provincial decision-support tools for facilitating local-scale monitoring and reporting. The provincial governments of KwaZulu-Natal, Eastern Cape, and Northern Cape are also engaged in enhancing their coverage and involvement. As part of the development of the provincial sub-systems, DFFE in collaboration with SAEON is committed to improving the overall functional and technical capabilities as well as the interface aesthetics of the National Climate Change Information System.

3.6.1.4 Climate Data Transparency through the NCCIS

The National Climate Change Information System (NCCIS) plays a central role in promoting transparency by providing open access to climate data. The NCCIS serves as a public platform that allows stakeholders and the public to access up-to-date information on South Africa's climate adaptation and mitigation efforts. This system helps facilitate the dissemination of climate information in a transparent and accessible way. Public dashboards present data on emissions, climate risks, adaptation measures, and other metrics, making it easy for users to understand and monitor climate-related progress. By making data publicly available, the NCCIS ensures that there is transparency in the reporting of climate actions and that the information is available for public scrutiny.

3.6.2 Impacts and achievements of monitoring and evaluation of climate change adaptation in South Africa

Monitoring and evaluation (M&E) of climate change adaptation is essential for tracking progress, identifying gaps, and ensuring that adaptation efforts are effective and sustainable. In South Africa, as in many other countries, robust M&E systems have enabled the government and stakeholders to assess the effectiveness of climate adaptation initiatives and make necessary adjustments.

- Informed policy adjustments: Monitoring and evaluation have provided critical feedback that informs the adjustment of climate adaptation policies and strategies. South Africa has refined and adjusted its National Climate Change Adaptation Strategy (NCCAS) and sector-specific policies based on findings from M&E activities, ensuring that they remain relevant and effective.

- Improved accountability and transparency: South Africa's National Climate Change Response Monitoring and Evaluation System has enabled transparent reporting to both national stakeholders and international bodies, improving accountability in the use of climate finance and public resources.
- Enhanced capacity building: M&E activities have contributed to capacity building across various sectors and institutions. By collecting data and evaluating adaptation projects, stakeholders gain valuable insights and technical knowledge that help improve future adaptation planning and implementation. This knowledge transfer also strengthens institutional capacity to manage climate risks in the long term.
- Data driven decision making: Data from M&E has led to targeted investments in climate-resilient infrastructure and agriculture, such as the introduction of climate-smart agricultural practices and the expansion of early warning systems for extreme weather events.
- International compliance and reporting: M&E systems enable South Africa to comply with its international climate reporting obligations, such as those under the Paris Agreement and the UNFCCC. Regular monitoring and evaluation provide the data needed for National Communications (NCs) and Biennial Transparency Reports (BTRs), ensuring that South Africa meets its transparency requirements on climate adaptation efforts.
- Integration of M&E into policy development: One of the main achievements of M&E efforts in South Africa is the successful integration of monitoring and evaluation into climate policy development. This ensures that adaptation measures are grounded in evidence and that policies can be adjusted in real-time to respond to changing climate conditions.
- Stakeholder engagement and collaboration: South Africa's M&E processes have facilitated greater stakeholder engagement, bringing together government

agencies, civil society, research institutions, and international partners. This collaboration has led to more comprehensive data collection and more effective adaptation projects.

3.6.3 Good practices and lessons learned from monitoring and evaluation of climate change adaptation in South Africa

Monitoring and evaluation (M&E) of climate change adaptation in South Africa has played a pivotal role in enhancing the effectiveness of adaptation measures and ensuring that policies and strategies are responsive to climate risks.

Some good practices include:

- Embedding M&E into national climate frameworks ensures that climate adaptation efforts are continuously assessed and refined, allowing for more responsive and effective adaptation strategies. South Africa has successfully integrated M&E processes into its national climate change policies, particularly through the **National Climate Change Response Policy (NCCRP)** and the **National Climate Change Adaptation Strategy (NCCAS)**. This integration ensures that adaptation efforts are systematically tracked, evaluated, and reported, with clear feedback loops into policy adjustments.
- South Africa's approach to M&E includes sector-specific systems that track adaptation efforts in critical areas such as water, agriculture, and biodiversity. This targeted approach allows for more detailed data collection and tailored evaluations, ensuring that specific challenges in each sector are adequately addressed.
- A key feature of South Africa's M&E system is the involvement of a wide range of stakeholders, including government departments, civil society organizations, research institutions, and local communities. This inclusive approach ensures that different perspectives and local knowledge are incorporated into the monitoring and evaluation process, resulting in more comprehensive assessments. Involving diverse stakeholders in M&E processes leads to more robust and inclusive adaptation strategies, as it integrates local knowledge and promotes community

ownership of adaptation initiatives.

- South Africa places a strong emphasis on using data and evidence to inform climate adaptation policies and projects. The **National Climate Change Information System (NCCIS)** and the **National Climate Change Response Database (NCCRD)** play crucial roles in collecting, storing, and analyzing climate-related data. This data-driven approach ensures that adaptation measures are based on scientific evidence and are more likely to succeed. Leveraging data and evidence for decision-making allows for more effective and targeted adaptation measures, as decisions are grounded in accurate assessments of climate risks and vulnerabilities.

Lessons learned include:

- Sector-specific M&E has allowed South Africa to tailor its adaptation responses to the unique challenges faced by different industries, resulting in more effective and resilient outcomes.
- One of the key experiences from South Africa's M&E efforts is the recognition of persistent data gaps, particularly in rural areas and in sectors like health and biodiversity.
- M&E has helped identify capacity-building needs within government agencies, municipalities, and local organizations involved in climate adaptation. Building institutional capacity has proven essential for the success of M&E systems, as it ensures that institutions are equipped to manage data, evaluate adaptation projects, and implement evidence-based solutions.
- South Africa has learned that investing in early warning systems is crucial for protecting communities from climate-related disasters such as floods, droughts, and storms. M&E has shown that well-functioning early warning systems can significantly reduce loss of life and economic damage by providing timely information that allows for proactive disaster management.
- A significant lesson learned is the challenge of coordinating climate adaptation

efforts across different sectors and levels of government. While progress has been made, M&E has revealed that better alignment is needed between national policies, local implementation, and sectoral priorities to ensure cohesive and integrated adaptation actions.

- South Africa's M&E processes have demonstrated that adaptation strategies need to be highly localized to be effective. Localized adaptation strategies, informed by local knowledge and conditions, are more likely to succeed and build resilience in vulnerable communities.
- M&E has highlighted that one of the ongoing challenges in climate adaptation is the limitation of resources and capacity, particularly at the municipal and community levels. Many adaptation projects are hindered by insufficient funding, technical expertise, and institutional capacity.

3.7 Information related to averting, minimizing and addressing loss and damage associated with climate change impacts

3.7.1 Major climate hazards and related economic and social impacts of severe weather events in South Africa

Climate change impacts and associated disasters pose significant economic, social, and environmental costs to South Africa. The country's vulnerability to climate change stems from its diverse geography, exposure to extreme weather events, and socio-economic challenges. The costs of climate change impacts and disasters in South Africa manifest across various sectors, including agriculture, water resources, infrastructure, health, and biodiversity. South Africa is vulnerable to a variety of climate extremes. Floods are the most frequent and widespread climate disaster, while droughts, veldfires, storms and heatwaves are the other significant extreme weather types contributing to loss and damage in South Africa.

Figure 3.14 shows the number and type of climate related disasters and associated economic impacts that have occurred over the past decade in South Africa. Several severe droughts have impacted South Africa in the past decade, including the 2015-2017 drought that caused a national water crisis in the Western Cape.

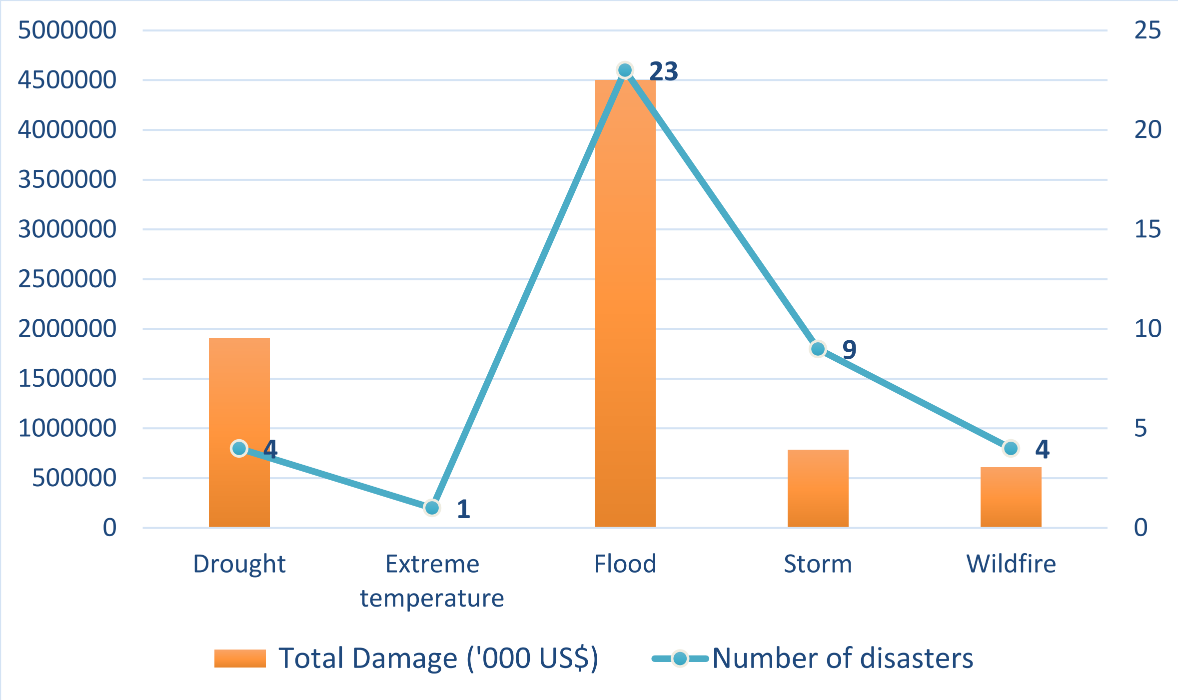

Figure 3.14. Number of declared climate related disasters and associated economic damage for the period 2013-2023 over South Africa (EM-DAT, 2024).

The impact of the drought had significant economic impacts across various sectors, particularly agriculture, tourism, and municipal services. The agricultural sector in the Western Cape, suffered severe revenue losses. The Western Cape Department of Agriculture estimated a loss of R5.9 billion (approximately USD 400 million) in agricultural revenue during the peak of the drought. The drought also led to significant job losses in agriculture. An estimated 30,000 seasonal workers and 50,000 permanent agricultural workers lost their jobs due to reduced farming activities. Key agricultural outputs, including fruit, vegetables, and wine grapes, saw substantial reductions. For instance, wine grape production declined by approximately 20% during the drought years (Pienaar and Boonzaaier, 2018).

Heat waves are also becoming more frequent and intense. The South African Weather Service reported record-breaking temperatures in some regions during the past five year. In January 2023, a severe heatwave affected regions like Gauteng and KwaZulu-Natal, with temperatures soaring up to 39°C. This extreme heat posed serious health risks, especially for vulnerable groups such as infants, the elderly, and outdoor workers

(SAWS). During November 2023, temperatures reached unprecedented highs, with Augrabies Falls recording 46.7°C on November 27. This marked one of the highest temperatures recorded in the Southern Hemisphere for that month (SAWS).

South Africa has experienced more frequent and intense floods, particularly along the eastern coast. In April 2022, Durban, Kwa-Zulu Natal, experienced devastating floods that caused widespread destruction and loss of life. Rainfall in excess of 350 mm over two days caused flash floods and mudslides, with flood water flowing through streets and settlements. At least 435 people lost their lives, and more than 40,000 people in total were affected by the floods and landslides. The cost of infrastructure and business losses amounted to an estimated US$2 billion (Grab and Nash, 2023).

Using published peer-reviewed methods, scientists from various countries collaborated to assess to what extent climate change contributed to the flooding in Kwa-Zulu Natal (Pinto et al., 2022). They found that climate change approximately doubled the probability of such extreme rainfall events, and they estimated that the intensity of the rainfall event was increased by 4-8% due to climate change. The report highlights that heavy rainfall events are projected to increase in frequency and magnitude in the future with additional global warming.

A climate change attribution study done by Liu et al (2023) on the 2021 wildfire in Cape Town that caused an estimated R1-billion in damages to the University of Cape Town alone found that climate change played a role and has significantly increased the chances of such devastating fires occurring in Cape Town. According to the study, CMIP6 models suggest that the extreme fire weather associated with the April 2021 Cape Town wildfire has become 90% more likely in a warmer world.

During June and July 2017, the town of Knysna in the Garden Route of the south coast, experienced one of the most destructive wildfires ever experienced in South Africa. Eight people lost their lives, over 100,000 hectares of land, including sections of Knysna National Park and Tsitsikamma National Park were burned, and more than 1,100 homes and businesses were destroyed, leaving many people displaced and facing significant financial losses.

These mentioned extreme weather events that were attributed to human induced climate change clearly illustrates the vulnerability of South African society and economy to global warming. Assessing loss and damage from severe climate events serves as a critical tool for understanding the true costs of climate change, informing effective responses, and promoting equitable solutions.

3.7.2 South Africa’s approach to reporting loss and damage from climate events

3.7.2.1 Policy Context

While there's no national policy specifically on Loss and Damage in South Africa, the National Disaster Management Act (2002) lays the foundation for disaster risk management in South Africa. It emphasizes a multi-hazard, multi-sectoral approach which includes assessing the impacts of disasters. The disaster management act also mandates the NDMC to submit a report to the Minister (who must table the report in Parliament) on the disasters that occurred, the classification, magnitude and severity of the disasters, as well as the effects they had. Organs of state must also report quarterly to the NDMC on the disasters, their impact and the expenditure incurred. The National Disaster Management framework outlines a coordinated approach to disaster risk management, including post-disaster needs assessments (PDNA). The PDNA is a crucial tool for evaluating the social, economic, environmental, and infrastructure impacts of disasters, including those related to climate change. The National Climate Change Adaptation Strategy (NCCAS) acknowledges the need for improved data collection and monitoring of climate change impacts. Implicitly, this includes assessing the impacts of climate-related disasters. Internationally, South Africa is also a signatory to the Sendai Framework for Disaster Risk Reduction (2015), which promotes a comprehensive approach to disaster risk management, including assessing disaster risks and losses.

3.7.2.2 Institutional context

In South Africa, the Department of Forestry, Fisheries and Environment acts as the leading government agency responsible for coordinating and overseeing the national climate change response, which include loss and damage from extreme climate events. Assessment of loss and damage through data collection, analysis and database development involves a collaborative effort between various government departments (national, provincial, and local levels) scientific institutions and the private sector.

Important role players at National level are the National Disaster Management Centre (NDMC) and the South African Weather Services. The NDMC serves as the national focal point for disaster response, coordinating the efforts of various government departments, provincial disaster management centres, and other stakeholders. The NDMC coordinates and supports damage assessments in the aftermath of extreme climate events. This involves evaluating the extent of damage to infrastructure, property, and livelihoods, which is crucial for allocating resources and planning recovery efforts. This ensures a comprehensive and standardized approach to gathering information.

The South African Weather Services (SAWS) plays a central role in assessing extreme climate events in South Africa by providing vital data, issuing early warnings, conducting climate analysis, disseminating information, and fostering collaboration. SAWS works closely with the National Disaster Management Centre (NDMC) and other government departments to develop a national Loss and Damage (L&D) reporting systems. They share weather information and forecasts to facilitate effective disaster preparedness, response, and recovery efforts.

Despite these extensive and dedicated efforts to collect, assess and analyse loss and damage related data in South Africa, there remains several gaps and challenges. These relate to limited human capacity and technical expertise, insufficient collaboration between different stakeholders involved in data collection and analysis, data fragmentation and inconsistency as well as limited focus on the indirect or intangible ripple effects of climate change that occur over time and can be more complex to quantify such as cultural and historical damage, mental health impacts and loss of ecosystem services.

3.7.3 Existing Loss and Damage Monitoring systems

South Africa's National Disaster Management Framework (NDMF) seeks the development of a comprehensive information and communications management system with links to relevant role players reporting on disasters. As part of the response and recovery component of the NDMF it requires the collection of disaster data related to the area affected, the type of event (classification by type, magnitude and severity), analysis of status of critical lifeline infrastructure and analysis of reported impacts and monitoring of progress. The NDMC therefore collects data on loss and damage in line with international guidelines and tools such as the Sendai Framework for Disaster Risk Reduction and the newly developed UNDRR hazardous event and disaster losses and damages tracking system which will replace the existing DesInventar system (Figure 3.15). South Africa as a country is therefore aligning its country level data collection initiatives to the available international loss and damage databases to allow for international reporting. Assessing the true cost of climate disasters is important to equip South Africa with data-driven arguments when negotiating for increased funding and support within the Loss and Damage framework.

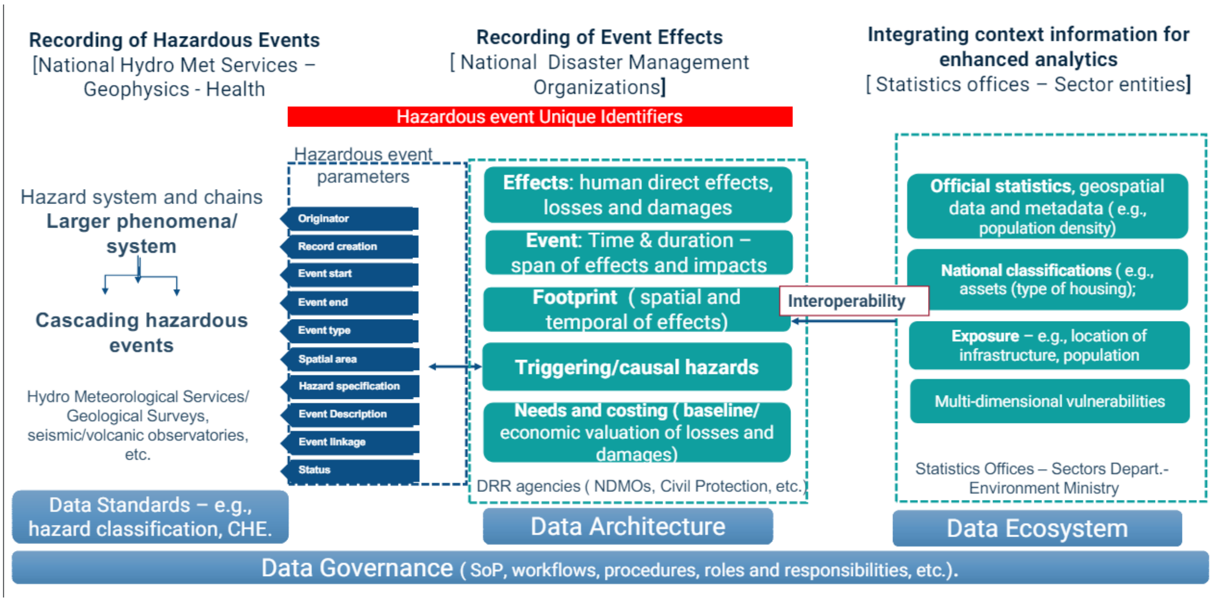

Figure 3.15. Schematic representation of the new model of losses and damages tracking (UNDRR).

The South African Weather Services is updating and improving its Severe Weather Impact Database. The Severe Weather Impact Database (SWID) is a comprehensive database maintained by the South African Weather Service (SAWS) that records and archives information on severe weather events and their impacts across South Africa (Figure 3.16). It includes data on various types of severe weather phenomena such as storms, floods, droughts, heatwaves, and wildfires, along with their associated impacts on infrastructure, agriculture, economy, and human lives. It is a standardized platform of archiving extreme weather systems, events and their impacts. It builds on the Caelum database which is a historical record of notable weather events that have impacted South Africa.

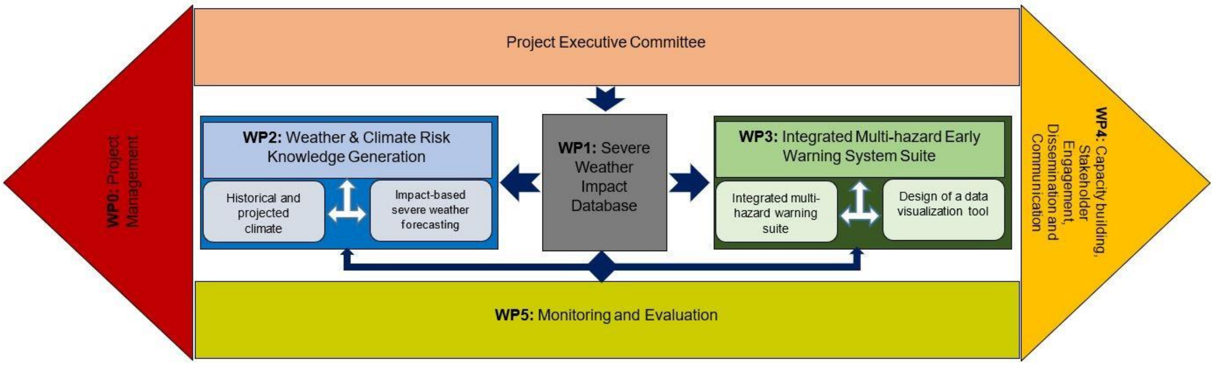

Figure 3.16: Severe Weather Impact Database (SWID)

3.7.4 National Dialogue on Loss and Damage

South Africa is an active participant in international discussions on L&D under the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts. South Africa has emerged as a leading voice for developing countries in international negotiations for the establishment of a Loss and Damage Fund to address climate change impacts. The country acts as a bridge between the developing countries and developed nations, facilitating dialogue and seeking common ground on L&D issues. This role is crucial for achieving progress in negotiations. South Africa emphasizes the specific needs of African countries facing the brunt of climate change impacts, such as sea level rise, extreme weather events, and desertification. This helps build a strong case for targeted financial assistance. Securing compensation for climate-induced loss and damage remains a complex issue. While the Loss and Damage Fund offers a promising step forward, South Africa will need to pursue a combination of approaches to ensure it receives adequate support for the losses and damages it experiences from climate change.

DFFE has therefore embarked on a process to improve the ability of South Africa to better report on loss and damage in the country. In this context, DFFE has initiated a National Dialogue on Loss and Damage. The primary objective of this initiative is to develop a comprehensive Loss and Damage Programme of Work for South Africa, ensuring a collaborative and coordinated response that aligns with global momentum on this issue. In pursuit of this objective, the DFFE, in partnership with various stakeholders, hosted three workshops aimed at establishing a coherent national approach to addressing loss and damage. These workshops facilitated discussions on the most effective strategies for South Africa, with specific goals to: enhance knowledge and understanding of approaches to address loss and damage; improve access to support, including finance, technology, and capacity-building; and strengthen dialogue, coordination, coherence, and synergies among relevant stakeholders.

The workshops resulted in several key outcomes, including: fostering stakeholder partnerships and collaboration to address loss and damage; identifying and mapping various economic and non-economic interventions at the national level; developing a comprehensive approach to implementing loss and damage interventions in South Africa; exploring innovative financial mechanisms to overcome institutional constraints in funding these initiatives; identifying research areas and strategies for managing and sourcing relevant data; and outlining processes for integrating loss and damage into monitoring and evaluation systems, as well as into national, subnational, and climate change policies and planning tools.

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4 Financial, technology development and transfer, and capacity-building support needed and received

The chapter provides an update from the previous Biennial Update Reports (BURs) on financial, capacity and technical support received and needed by South Africa between 1 Jan 2021 and 31 Dec 2022. The chapter presents an analysis of international and domestic climate-related finance flows, as well as non-monetised support, received within the reporting period.

South Africa's national circumstances are described in the context of the climate finance landscape and institutional arrangements relevant to reporting on financial, technology and capacity building support needed and received. The international financial support received/committed and domestic funds received/committed through government grants and loans are outlined in the sections that follow. Capacity building and technology support received from international donor funding sources, as well as financial support needed (or requested) by South Africa to develop its response to climate change by sector is described.

4.1. National circumstances, institutional arrangements and country-driven strategies

4.1.1. National Circumstances

South Africa is a signatory to numerous global climate change responses including the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, and the Paris Agreement. The country has developed overarching policies and frameworks to support climate change responses which are guided by Section 24 of the Constitution of the Republic of South Africa (RSA, 1996), the National

Development Plan 2030 (NDP 2030) (NPC, 2011), the National Climate Change Response Strategy (NCCRS) (2004), and National Climate Change Response Policy (NCCRP) (DEA, 2011) which builds on the NCCRS.

South Africa's enabling policy, institutional, and regulatory framework for climate-related investments in mitigation, adaptation and a just energy transition demonstrates the country's resolve to fundamentally restructure the electricity sector, address energy insecurity and energy poverty, and build human capital for a new energy economy (Figure 4.1). Implementation of these policy interventions needs to be matched with adequate finance, technology and capacity building support.

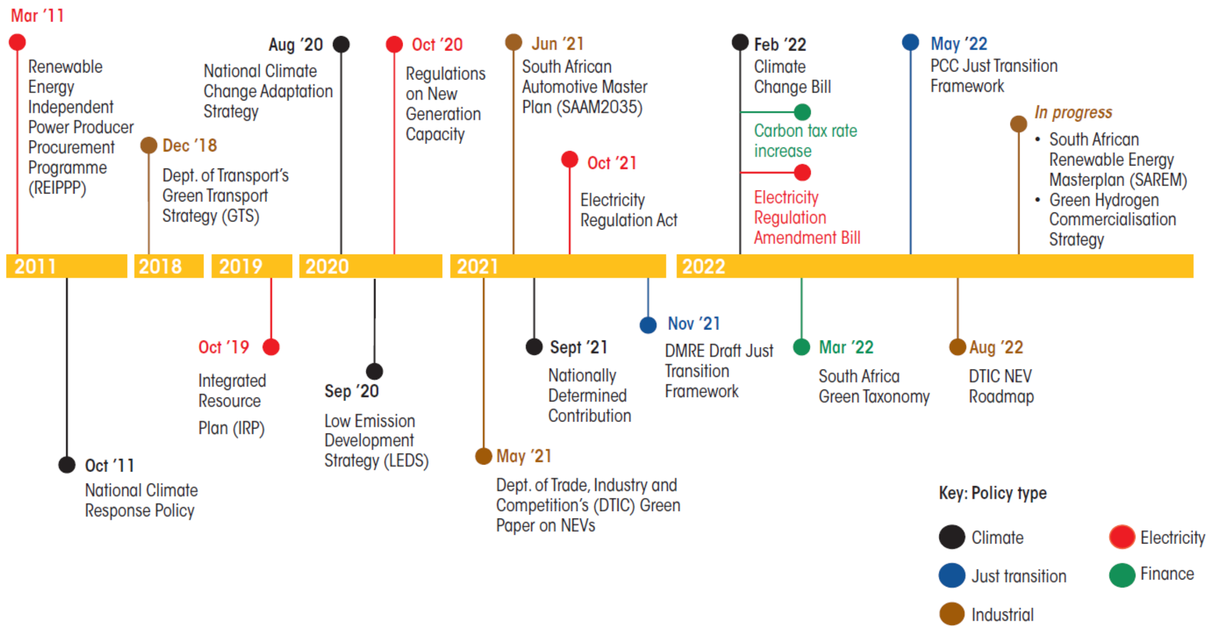

Figure 4. 1 The enabling policy, institutional, and regulatory framework for climate-related investments in mitigation, adaptation and a just energy transition (Source: PCC, 2022a)

South Africa's National Climate Response Policy (NCCRP) (DEA, 2011) informs both mitigation and adaptation planning. The NCCRP explicitly calls for the inclusion of the financial sector and the employment of a wide range of traditional as well as innovative finance instruments to achieve climate compatible development of the economy.

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

South Africa has defined and adopted a clear roadmap on climate change mitigation and adaption. In the case of climate change mitigation, the Low Emission Development Strategy (2050) submitted to the UNFCCC in 2020 provides an overarching framework for achieving the country's mitigation ambition under the Paris Agreement in line with the NDC commitment. The LEDS sets out a long-term decarbonisation trajectory for key economic sectors and identifies actions required to achieve this. The country's roadmap on adaptation is guided by the National Climate Adaptation Strategy which plays the role of the country's National Adaptation Plan (DFFE, 2020). The NCCAS communicates the country's adaptation priorities and gives effect to the National Development Plan's (NDP) vision of creating a low-carbon, climate resilient economy and a just society.

South Africa's updated Nationally Determined Contribution (NDC), communicated to the UNFCCC secretariat in October 2021, reaffirmed the country's commitment to making a fair contribution to global efforts to address climate change. The NDC, which is the cornerstone of the South Africa's climate response, is a means of communicating the country's high-level vision and objectives on climate action to the international community by addressing the country's climate change ambitions on mitigation, adaptation, and a just transition in a comprehensive way. The updated NDC is framed within the context of the Paris Agreement, and addresses the implementation support to be provided by developed countries in terms of Articles 9–11 (finance, technology, and capacity building) and the degree of mitigation ambition that can be achieved by a developing country. In this context, South Africa has committed to achieving an emissions target in a range between 350 - 420 $MtCO_2$-eq by 2030, dependent on the level of support received.

South Africa is gearing up domestic action to achieve its enhanced ambition under the Paris Agreement. The Climate Change Bill was developed in recognition of the country's need to strengthen its climate change mandate. The Bill was tabled in Parliament in February 2022 and went through various public participation and law-making processes to become South Africa's Climate Change Act when it was signed into law by the President of South Africa on 23 July 2024. The Climate Change Act, as endorsed by the President, mobilizes South African society towards a climate-resilient and low-carbon economy. In terms of climate finance, the Act provides the mechanisms to support and finance the climate change response, providing guidance and a governance framework to promote planning and implementation by national, provincial and local government.

Tools and/or assessments to track and report support needed and received include the Climate Finance Landscape Analysis, the Climate Finance Accelerator, the Climate Budget Tagging (CBT) system, the Green Finance Taxonomy, and the JET Projects' Register.

Climate finance landscape analysis

South Africa undertook an update to the South African Climate Finance Landscape 2020 report (CPI, 2021). The previous report tracked climate finance for the years 2017 and 2018, while the South African Climate Finance Landscape 2023 report (de Aragão Fernandes, 2023) covered 2019, 2020 and 2021, sourcing data from both domestic and international sources. The report aimed to map climate finance investment in South Africa by way of tracking project-level investments thereby identifying sources and intermediaries of climate finance; financial instruments used; uses of climate finance; and describing which sectors benefit from climate finance flows in South Africa. A key insight from the report is that climate finance in South Africa needs to increase by at least three to fivefold from the current annual average of R131 billion.

Estimates suggest that South Africa requires on average R334 billion per year to meet its net zero goal by 2050, and R535 billion per year to meet its NDC target by 2030 (de Aragão Fernandes, 2023).

An analysis of various studies undertaken by several organisations was conducted as part of South African Climate Finance Landscape 2023 report to better understand the costs associated for South Africa to transition to a low carbon society, deliver on South Africa's net zero ambitions and reach energy security. Estimates of South Africa's annual climate finance needs vary depending on studies' timeframe, sectoral focus and methodological approach, demonstrating the need for more comprehensive and granular analysis (de Aragão Fernandes, 2023).

For the purpose of the SABTR1, the information on financial support needed in Section 4.3 will be informed by estimates from the Just Energy Transition Investment Plan (PCC, 2022).

The Climate Finance Accelerator (CFA)

The Climate Finance Accelerator (CFA), a technical assistance programme launched in 2021, is funded and promoted by the Department of Business, Energy and Industrial Strategy of the United Kingdom Government (BEIS) and implemented in South Africa by the National Business Initiative (NBI) and GreenCape as the in-country partners.[2]

The purpose of the programme is to improve the flow of finance to low carbon projects in South Africa. The CFA is a global technical assistance programme funded by the UK International Climate Finance to support countries efforts in implementing their NDCs under the Paris Agreement. The programme supports climate project proponents to improve the bankability and appeal to financiers of their projects. A

[2]https://www.nbi.org.za/wp-content/uploads/2023/02/PRESS-RELEASE-UK-GOVERNMENT-SUPPORTS-CLIMATE-PROJECTS-IN-SOUTH-AFRICA-1-1.pdf

Climate Budget Tagging (CBT) system will be implemented to quantify and track expenditure on climate relevant activities.

In October 2021, the Climate Finance Accelerator (CFA) South Africa announced 13 innovative low carbon projects that it will support to access finance from investors following a call for proposals that attracted 120 applications[3]. Projects in the CFA cohort were from a range of sectors including waste management, energy and transport. Some of the projects aimed to increase sustainable mobility alternatives in cities while reducing emissions, whilst others aimed to support the growth of renewable energies in South Africa. To ensure the selected projects are in the best position to attract investment from South African and international financiers, the projects will receive capacity building support in areas such as low-carbon technologies, blending finance from public and private sources, as well as advice on enhancing gender, equality and social inclusion.

The CFA in South Africa began its second phase in July 2022 and launched a call for proposals to support low-carbon projects fighting climate change and looking for investment[4]. The projects should be at least in the pre-feasibility stage and require at least USD$4 million.

Green Finance Taxonomy

A draft Technical Paper on "Financing a Sustainable Economy" was published by National Treasury in May 2020 with the aim of unlocking access to sustainable finance and stimulating the allocation of capital to support a development-focused and climate-resilient economy. One of the recommendations of the paper was to "develop or adopt

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[3]https://www.nbi.org.za/wp-content/uploads/2023/02/PRESS-RELEASE_-CLIMATE-FINANCE-ACCELERATOR-SOUTH-AFRICA_FIRST-COHORT-OF-PROJECTS-ANNOUNCED.pdf

[4]https://www.nbi.org.za/wp-content/uploads/2023/02/PRESS-RELEASE-UK-GOVERNMENT-SUPPORTS-CLIMATE-PROJECTS-IN-SOUTH-AFRICA-1-1.pdf

a taxonomy for green, social and sustainable finance initiatives, consistent with international developments, to build credibility, foster investment and enable effective monitoring and disclosure of performance". As a result, South Africa's Green Finance Taxonomy (GFT) project was developed by the Taxonomy Working Group, as part of South Africa's Sustainable Finance Initiative, chaired by National Treasury. South Africa is leading by example, with a public institution, such as the National Treasury, proactively addressing climate compatible financial system development. South Africa is the first and, so far only African country that has developed a green finance taxonomy (GIZ, 2023).

The first edition of the South African Green Finance Taxonomy (GFT 1st Edition) (NT, 2022a) outlines the results of the work to date in developing the 1st Edition of the South African Green Finance Taxonomy for environmentally sustainable economic activities. The Green Finance Taxonomy is a classification system for defining which assets, and projects substantially contribute to climate change adaptation and mitigation. The taxonomy has found widespread acceptance among stakeholders, which can largely be attributed to the extensive consultation process conducted for its development (GIZ, 2023).

The Taxonomy is intended to have a range of benefits, which, amongst others, include (NT, 2022a):

- Helping the financial sector with clarity and certainty in selecting green investments in line with international best practice and South Africa's national policies and priorities.
- Reducing financial sector risks through enhanced management of environmental and social performance.
- Reducing the costs associated with labelling and issuing green financial instrument.
- Unlocking significant investment opportunities for South Africa in a broad range of green and climate-friendly assets.
- Supporting regulatory and supervision oversight of the financial sector.
- Providing a basis for regulators to align or reference green financial products.

Climate Budget Tagging (CBT) system

Under the auspices of the National Treasury, South Africa is developing a CBT system to support climate-centric budget reform. National Treasury (NT) initiated the design and piloting of a climate budget tagging (CBT) system for South Africa in October 2020. The work was conducted with the support of the Nationally Determined Contribution Support Facility (NDC-SF), a multi-donor Trust Fund administered by the World Bank, with Mokoro/OneWorld appointed as a service provider to the NT (NT, 2022b).

CBT involves classifying and tagging public expenditure according to its expected contribution to climate change mitigation or adaptation. The intent is to implement a CBT system at all three levels of government (national, provincial and local government), given the distribution of expenditure responsibilities in key climate change sectors. The stakeholders of CBT include the Department of Forestry, Fisheries, and the Environment (DFFE), Department of Planning, Monitoring and Evaluation in the Presidency (DPME), Cooperative Governance and Traditional Affairs (CoGTA), and provincial and local government representatives.

The rationale for implementing CBT in South Africa is that it would (NT, 2022b):

- Contribute to raising awareness on and knowledge of climate change impacts on service delivery in public institutions;
- A tool for integrating or mainstreaming climate change and the just transition into policies, strategies, plans, programme design, and macro-fiscal and budget planning at all three levels of government, and in public entities;
- Provide systematic and credible evidence of existing spending, and is needed for the estimation of the funding gap for achieving South Africa’s NDCs, among other policy objectives;
- Potentially strengthen climate strategies and plans by ensuring consistency in the definition of climate expenditure between strategies and the budget;
- Provide spending data that can be used to analyse trends and assess effectiveness; and improving the prioritisation of climate resources against national, provincial, and local climate strategies;

- Provide the evidence for coordinating and tracking how climate change responses are distributed across sectors, and the components (main departments and public entities) and levels of government;
- Support better accountability of departments, municipalities, and entities for the climate response responsibilities; and
- Signal commitment to climate change responsiveness and provide the base for attracting and managing green financing and support climate-aware public investment.

The CBT Project Stage I was initiated in October 2020. Between October 2020 and June 2022 the Project consulted on the needs for and objectives of a CBT system for South Africa, conducted awareness raising workshops, reviewed international experience, conducted capacity needs assessments, designed a draft CBT system for South Africa and tested the system in nine pilot sites with selected national and provincial government departments, a public entity, as well as metropolitan and local municipalities (NT, 2022b). The pilots were conducted in the water, energy, transport, and agriculture sectors.

JET Projects' Register

At COP26 in 2021, the International Partner Group (IPG) made up of Germany, France, the US, the UK and EU pledged US$ 8,5 billion in a Political Declaration to support South Africa's Just Energy Transition through a combination of grants, concessional loans, and commercial debt and equity (RSA, 2024). In 2023, Netherlands and Denmark joined the IPG. Including JET pledges from Spain, Switzerland and Canada, the international pledges to the South African JET IP have increased to US$ 11,7 billion. Of the total amount pledged, US$ 821 million has been committed to grant financing (RSA, 2024).

The JET Project Management Office (JET PMU) created a JET Projects' Register in the interest of accountability, oversight, and transparency, which is updated quarterly. Working with the IPG and other partner countries, the first phase of building the Register has been to document all the grant allocations that have been made by the international partners, per Portfolio, since November 2021 when the Political Declaration was signed between South Africa and the IPG at COP26. Note: Others, including philanthropy organisations and private sector donors, are contributing to the Just Energy Transition but are not yet included in the JET Grants Register. It is anticipated that these contributions can be recorded in the JET Grants Register in due course (RSA, 2024).

4.1.1. Institutional arrangements

The institutional arrangements relevant to reporting on financial, technology and capacity support needed and received are illustrated in Figure 4.1 in terms of data providers and the flow of information from various directorates within the DFFE who are responsible for outputs to the United Nations Framework Convention on Climate Change (UNFCCC), *viz.* National Communications, Biennial Transparency Reports and Nationally Determined Contributions.

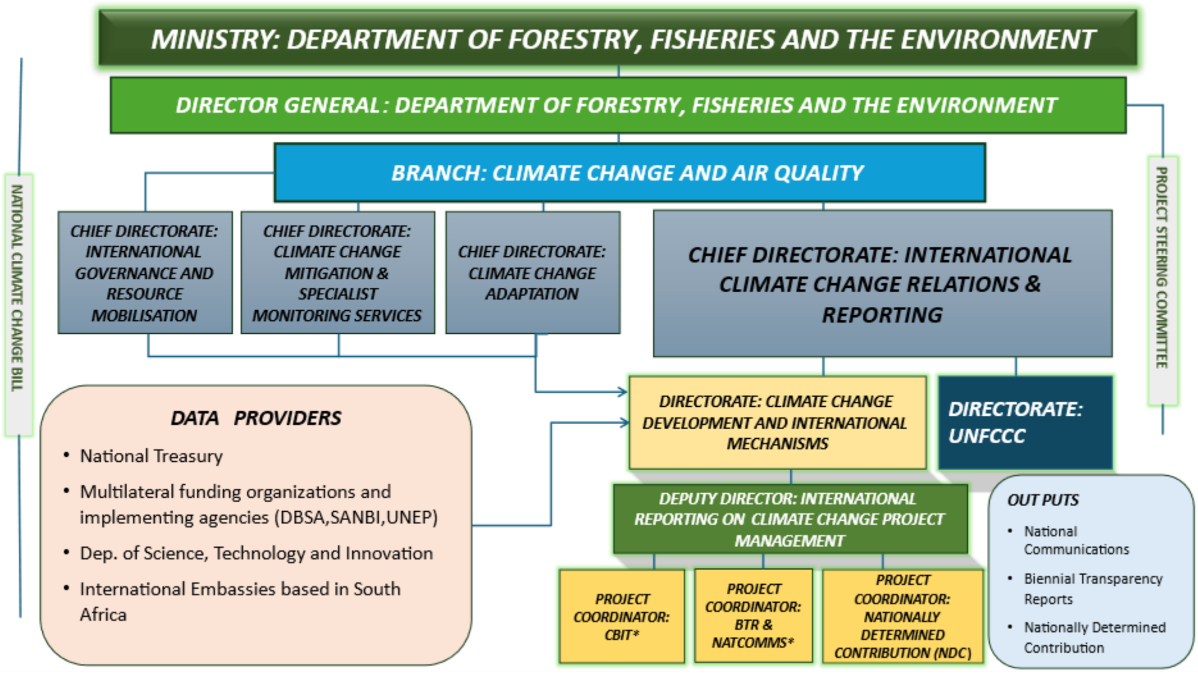

Figure 4. 2 Institutional arrangements relevant to reporting on support needed and received

Tracking of Financial support received

The National Treasury manages South Africa’s national government finances. The National Treasury provides data on some of the bilateral climate financial support received to the Department of Forestry, Fisheries and the Environment (DFFE) for inclusion in the Biennial Transparency Report (BTR). The data is processed and analysed through the Directorate: Climate Change Development and International Mechanisms (CCD&IM) for inclusion in the BTR.

Some of the climate data on bilateral financial support received is collected annually through a standardised template by the Climate Change Mitigation Research and Analysis from the international embassies in Pretoria. It is analysed by the Chief Directorate and shared with the CCD&IM Directorate for inclusion in the BTR.

The data on multilateral financial support received is sourced from the multilateral funding organisations, mostly from the websites such as the GEF and GCF as well as the implementing agencies such as the DBSA, SANBI, UNEP etc. Some of the multilateral financial support received is tracked from the International Governance and resource mobilisation Chief Directorate who are also responsible for this function. The data is also shared with the CCD&IM Directorate for inclusion in the BTR. The tracking of financial support in South Africa is not centralised, data is collected from different entities, thereby making it challenging to track.

Tracking and coordination of financial support needed

The DFFE, through the Chief Directorate International Climate Change Relations and Reporting often mobilises resources from enabling activities projects funded by the GEF. The Directorate: CCD&IM, part of the DFFE, oversees the tracking and coordination of financial support needed to address climate change. Working closely with other Chief Directorates and Project Steering committee and other relevant entities, CCD&IM ensures that financial resources needs are documented and reported in the BTR. This collaborative approach aims to enhance South Africa's ability to mitigate and adapt to climate change impacts, promoting sustainable development and environmental responsibility nationwide.

Technology Transfer and Development Support Needed and Received

The Department of Science, Technology, and Innovation (DSTI) is mandated to lead the technological needs assessment for South Africa. DSTI collaborates closely with the DFFE and other relevant organizations in this regard in conducting the technology needs assessment (TNA) study (CSIR, 2019), which was an updated assessment of South Africa's climate technology needs across key sectors to both adapt to and mitigate climate change effects to achieve sustainable developmental goals. The scope of the TNA included the prioritisation of sectors and technologies that support adaptation and mitigation measures based on a review of policy, a barrier analysis to assess barriers to implementation of prioritised technologies as well as barriers to technological innovation, and a synthesis of the country's actions/ planned activities towards supporting the deployment of selected prioritised technologies. The DFFE, through the Chief Directorate International Climate Change Relations and Reporting mobilised resources from enabling activities projects funded by the Global Environment Facility (GEF) and collaborated with the DSTI in hiring the service provider to assist with conducting the TNA study. The results of the TNA study are then used by the CCD&IM Directorate for inclusion in the BUR/BTR.

Capacity Building Support Received

The Directorate: CCD&IM is responsible for coordinating and tracking capacity building support received. The Directorate does this in consultation with the Chief Directorates: Climate Change Mitigation & Specialist Monitoring Services and Climate Change Adaptation, in terms of capacity building support received, and tracks all of it for reporting in the BTR. Through the PSC the Chief Directorate: International Climate Change Relations and Reporting, also tracks on the capacity building support received on the Measurement Reporting and Verification of climate change reporting in the BTR.

Capacity Building Support needed

The CCD&IM Directorate coordinates with the Chief Directorates: Climate Change Mitigation & Specialist Monitoring Services and Climate Change Adaptation, in terms of their capacity building needs. Within the Climate Change Mitigation and Specialist Monitoring Services Chief Directorate the Climate Change Monitoring and Evaluation: Mitigation Response Analysis: GHG Inventory and Systems Directorate coordinates the GHG Inventory in terms of their priorities for the GHG improvement Plan. The coordination also done with the other Directorates on NDC tracking and the development of projections.

The CCD&IM Directorate also coordinates with the adaptation Chief Directorate in terms of Capacity building needs. For example, coordination is done with Monitoring and Evaluation of adaptation on the development of indicators, the Climate Change CCD&IM Directorate overseeing the tracking of support and capacity-building needs. This Directorate collaborates closely with other Directorates to ensure comprehensive reporting. Specifically, it coordinates efforts to track the support and capacity-building needed and received.

The Project Steering Committee (PSC), established by the Director General of the DFFE, continues to support contributing authors in providing technical inputs and oversight on the compilation of these reports. This includes reviewing and commenting on the content of the reports, to ensure that they accurately reflect national circumstances.

4.2. Underlying assumptions, definitions and methodologies

Presentation of tables in chapter

The SABTR1 covers the period from 1 Jan 2021 – 31 Dec 2022. The format of tables presented in the report the BTR tables in Decision 5/CMA.3, specifically Tables 3.7 to 3.12. Note, due to limited space in presenting tables, selected columns were not illustrated in the chapter, however, this information for these columns is included in the Excel spreadsheets for the relevant sections that supported the compilation of the chapter.

Currency conversion

The currency conversion rate to convert domestic currency into United Stated Dollars (USD), Euros (EUR), and Swiss Franc (CHF) is shown in Table 4.1.

Table 4. 1. Currency conversion for reporting period in the SABTR1

Currency	2021 (ZAR)	2022 (ZAR)	Average ZAR 2021-2022
USD TO ZAR	14.84	16.41	15.63
EUR To ZAR	17.59	17.31	17.45
CHF To ZAR	16.31	17.29	16.80

Allocation of funding Green Climate Fund projects approved for South Africa

As per the GCF website[5], or multi-country projects, financial information per country is equally divided unless the allocation % is specified. As such, the total funding committed for South Africa for projects funded by GCF was calculated by dividing the total funding by the number of countries supported.

4.3. Financial support needed

South Africa’s climate finance needs are informed by the revised targets proposed in South Africa’s revised NDC lodged with the UNFCCC in 2021, as well as on the Just Transition Investment Plan (JET IP) (2023-2027). The basis for South Africa’s NDC is the assumption that support will be provided for the implementation of the targets and goals therein, for mitigation, adaptation and loss and damage. The country requires support for a just transition towards net zero CO_2 emissions and with the increased level of mitigation ambition communicated in the NDC, international support will be required, with the key to the increased level of mitigation ambition lying in the electricity sector (RSA, 2021). In addition, support will also be required for longer term decarbonisation, which will require investments in the 2020s towards infrastructure, technology development and capacity-building (RSA, 2021). Over the next decade, the NDC will require a greater investment programme, as specified in IRP 2019, of

[5] GCF - https://data.greenclimate.fund/public/data/projects

between R 860 billion and R 920 billion (in 2019 Rands; USD 60-64 billion). The shift away from coal that IRP 2019 requires will require support in the form of transition finance and associated technology and capacity-building.

South Africa's JET IP 2023–2027 sets out the scale of need and the early-stage investments required for the country's Just Transition (JT) to a low-carbon and climate-resilient economy in line with its updated Nationally Determined Contribution (NDC). Achieving the JET IP outcomes is dependent on the scale and nature of financial support that South Africa can secure from the international community to complement domestic resources. To decarbonise South Africa's economy within the NDC target range of 350–420 Mt CO_2eq by 2030, will require approximately ZAR 1.48 trillion (US$ 98.7 billion)[6] over five years from multiple sources. These sources include developed countries; private sector investors; Development Finance Institutions (DFIs); Multilateral Development Banks (MDBs); government; and philanthropies.

The JET Implementation Plan 2023-2027 is a roadmap that enables South Africa to take targeted and aligned strides towards meeting its decarbonisation commitments in a manner that will deliver just outcomes for the people affected by the energy transition and that contributes to inclusive economic growth, energy security, and employment (PCC, 2023). Various Just Energy Transition (JET) initiatives are underway in South Africa which are led by government institutions, the private sector, and civil society organisations. Finance for these initiatives is through government programmes, by partner governments, Development Finance Institutions (DFIs), Multilateral Development Banks (MDBs), philanthropies, corporate social investments, impact investors, and commercial investors. However, further funds can and must be mobilised at scale for the JET IP once there are firm pathways to achieving defined outcomes. These pathways need to be underpinned by unambiguous government policy and leadership, good governance, and institutionally co-ordinated effort.

Investments are needed in three priority sectors: electricity, New Energy Vehicles (NEVs), and Green Hydrogen (GH_2). More specifically, investment is needed in our

[6] The exchange rate used throughout the JET IP: 15:1. (PCC, 2022)

electricity transmission and distribution networks and dramatically expanding renewable energy generation, as well as investment in local production of green hydrogen and electric vehicles, and investing in local economies to develop skills and enable economic diversification.

Further investments are needed in two cross-cutting areas: skills development and municipalities (PCC, 2022). The summary of the JET IP funding requirements per sector is presented in Table 4.2. Investments needed for skills development includes support for the development of a national skills plan for a just energy transition and the future of work to ensure that skills are in place to match the growth in new clean sectors and support worker transition. The five-year investment needs for skills development also included funding for pilot skills development Zones in Mpumalanga, Eastern Cape and Northern Cape, as well as mobilising allocations to JET from existing public and private post-school education and training (PSET) funding per annum (PCC, 2022).

The second set of cross-cutting investments needed targets specific support for municipalities to navigate the energy transition and play a dynamic and responsive role in the energy system for the benefit of the communities they serve. This requires functional distribution grids that can accommodate an increasing penetration of renewable energy generation at different scales and connect all residential, public, commercial, and industrial energy users. It also requires the establishment of a financially sustainable service delivery model that provides for equitable access by the whole grid community, all local energy users, including small businesses and low-income and energy-poor households (PCC, 2022)

For each of the three priority sectors, the ZAR1.48 trillion (US$98.7 billion) financing targeted for the JET IP is categorised under infrastructure, planning and implementation capacity, skills development, economic diversification and innovation, along with social investment and inclusion (Table 4.3).

Table 4. 2. JET IP funding requirements per sector, 2023–2027 (PCC, 2022)

JET IP funding requirements 2023-2027	ZAR billion	USD billion
Electricity sector	711.4	47.2
New Energy Vehicle (NEV) sector	128.1	8.5
Green Hydrogen (GH_2) sector	319.0	21.2
Skills development	2.7	0.18
Municipal capacity	319.1	21.3
TOTAL	**1 480.3**	**98.38**

Table 4. 3. Financing needs of the JET IP for the period, 2023–2027 (PCC, 2022)

ZAR (US$) billions	Electricity	NEV	GH_2	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 (68.7)	128 (9)	319 (21)	
TOTAL				**1 480 (98.7)**

The estimated availability of funding per sector and source, together with the outstanding funding to meet targets, is illustrated in Figure 4.3. (*Note: The funding gap and scale of need is indicative and assumes the commitments and pledges of the funded portions materialise).

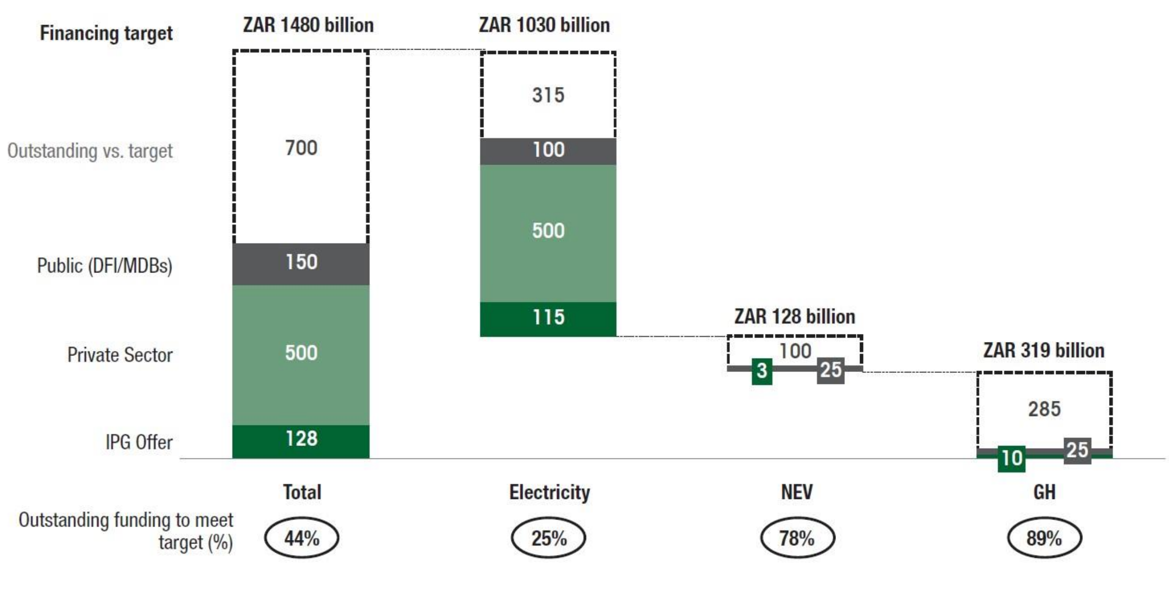

Figure 4. 3: Projected funding needs and estimated availability by source (PCC, 2022).

The Paris Agreement and the recent Glasgow Agreement at the 26th Conference of the Parties (COP) in 2021 have led to a major international commitment to financially support the implementation of NDCs in developing and emerging countries. South Africa has been one of the early beneficiaries of the Glasgow Agreement where a Just Energy Transition Partnership (JETP) was forged between South Africa and the governments of France, Germany, United Kingdom, the European Union, and the United States (forming the International Partners Group [IPG]). As part of this partnership, the IPG undertook to mobilise US$8.5 billion over five years to support South Africa's Just Energy Transition. The initial IPG offer of US$8.5 billion is thus a catalytic contribution towards addressing the JET IP priorities. In the context of the JET IP's identified scale of need for investment in the priority sectors of Electricity, New Energy Vehicles (NEVs) and Green Hydrogen (GH_2), the JET IP outlines how the IPG pledge of US$8.5 billion will be allocated to these priorities in South Africa over five years (Table 4.4).

Table 4. 4 Allocation of US$8.5 billion pledge for the period, 2023–2027 (PCC, 2022)

IPG US$8.5 billion allocation, 2023–2027	Electricity	NEV	GH_2
Infrastructure	6.9	0.2	0.5
Planning and implementation capacity	0.7		0.2
Skills development	0.012		
Economic diversification & innovation	0.022		
Social investment and inclusion	0.016		

4.4. Financial support received

Climate finance sources for South Africa can be classified into four different categories: bilateral finance, multilateral finance, domestic public finance and private sector finance. Support is classified as 'bilateral' if it comes from one donor country and as 'multilateral' if more than one country/entity provides the support and it is channelled through one donor agency. Bilateral assistance for climate change comes in different forms; through individual donors, through donor agencies, directly in the form of Official Development Assistance (ODA) and through bilateral finance institutions. The international financial support committed, and domestic funds committed through government grants and loans, are reported in the sections that follow.

4.4.1. International financial support received

Detailed information on the breakdown of the international bilateral and multilateral financial support received has been reported in South Africa's Biennial Update Reports (BURs) since 2014 when the country's first Biennial Update Report was submitted. South Africa has submitted a total of five BURs between 2014 and 2023 (Table 4.5). The SABTR1 will include bilateral and multilateral support received for the period 1 Jan 2021 – 31 Dec 2022.

Table 4. 5. Reporting of bilateral and multilateral support in South Africa's BURs

BUR	**Reporting period**	**Tables with bilateral and multilateral support**	**Reference**
BUR-1	2000-2010	Tables 28 and 29	DEA, 2014
BUR-2	2010-2014	Tables 34 and 35	DEA, 2017
BUR-3	2015-2017	Tables 4.1 and 4.2	DEA, 2019
BUR-4	2018-2019	Tables B1.1 and B2.1	DFFE, 2021
BUR-5	2020*	Tables 4.1 and 4.2	DFFE, 2023

Note: *It was agreed that data for 2021 would not be included in the BUR-5 since it will be reported in the country's first Biennial Transparency Report (SABTR1).

In South Africa, bilateral and multilateral development and donor agencies have played a substantial role in funding and providing technical assistance in relation to climate mitigation, climate adaptation, climate finance and climate compatible financial system development.

The International Climate Finance that is unlocked through the Conference of the Party (COP) COP process is channelled through the COP Financing Mechanism which currently consists of three Funds, *viz*. the Green Climate Fund (GCF), the Global Environmental Fund (GEF), and the Adaptation Fund.

The Development Bank of Southern Africa (DBSA) is an Accredited Entity in South Africa through which project proposals can be submitted to the Green Climate Fund for funding consideration. The DBSA also manages South Africa's Green Fund and manages a Climate Finance Facility. A Project Preparation Facility which provides support and finance for early project preparation is also hosted through the DBSA, and this can assist in bringing project proposals to a level of bankability.

Implementing agencies of multilateral funds in SA also include the World Bank, International Union for Conservation of Nature (IUCN), and Energy Environment Partnership Africa (EEPA).

Other bilateral and multilateral development and donor agencies include the African Development Bank (AfDB), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Kreditanstalt für Wiederaufbau (KfW), Agence Française de Développement

(AFD), Government of Norway, UK Foreign, Commonwealth & Development Office (FCDO), Green Climate Fund (GCF), International Finance Corporation (IFC) and UN Environment (GIZ, 2022).

Over the reporting period for 2021 and 2022, South Africa received in excess of USD$ 5 149 million in bilateral support and US$ 25.8 million from multilateral sources that support or benefit climate change actions in the country.

The bilateral support received in the reporting period was in the form of grants, loans, technical assistance, guarantees and combination of the above. Overall, the United Kingdom accounted for the largest share of climate finance committed between 2021 and 2022, supporting the Energy sector (e.g. Just Energy Transition Partnerships, Just Transition Finance Roadmap (JTFR), and private sector opportunities (Figure 4.4). Table 4.6 provides the spilt across funding instruments, with the bulk of the funding received in the form of loans.

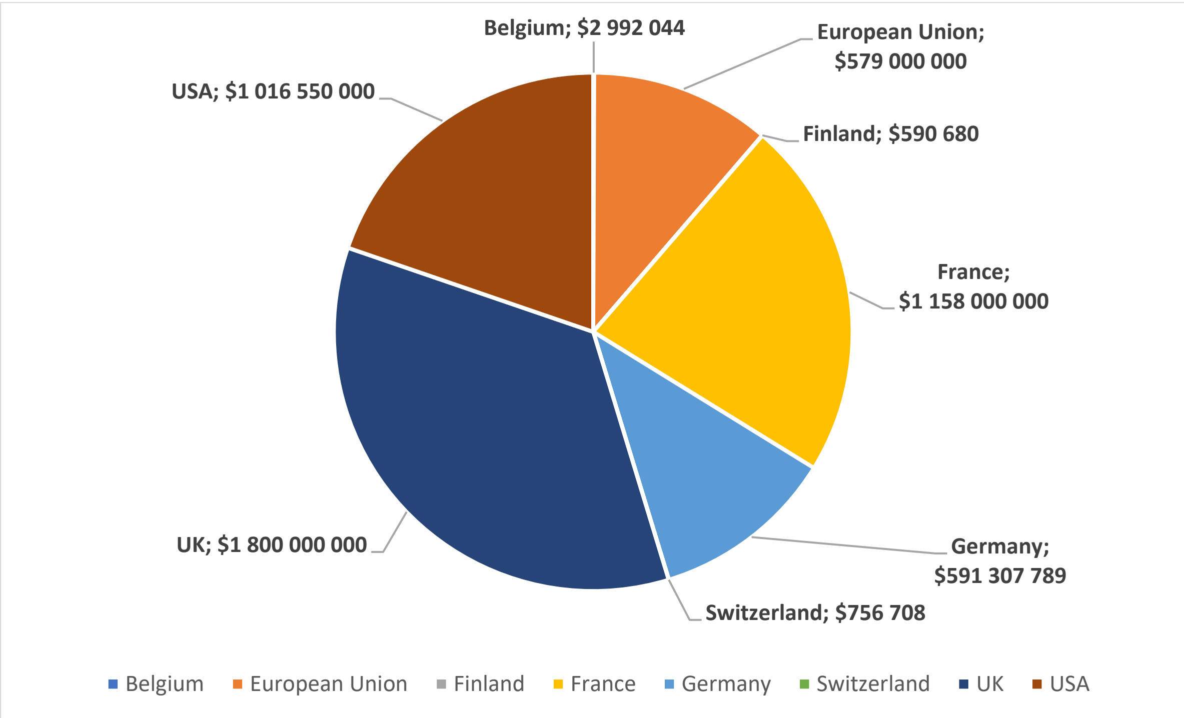

Figure 4.4: Percentage contribution of bilateral support per donor funder between 1 Jan 2021 – 31 Dec 2022

Table 4. 6. Bilateral funding split across financial instruments (USD)

Bilateral Total 21-22	Grant	Loan	Technical assistance	Guarantee	Combination
$5 149 197 222	$196 699 522	$2 049 660 000	$402 837 700	$1 000 000 000	$1 500 000 000

The multilateral support received in the reporting period was in the form of grants, loans, and equity. The GCF and EU contributed 44.7% and 35.5% of the total multilateral support received, respectively, followed by UNEP (12.4%) (Figure 4.5). Table 4.7 provides the spilt across multilateral funding instruments, with the bulk of the funding received between 2021 and 2022 in the form of grants (63%).

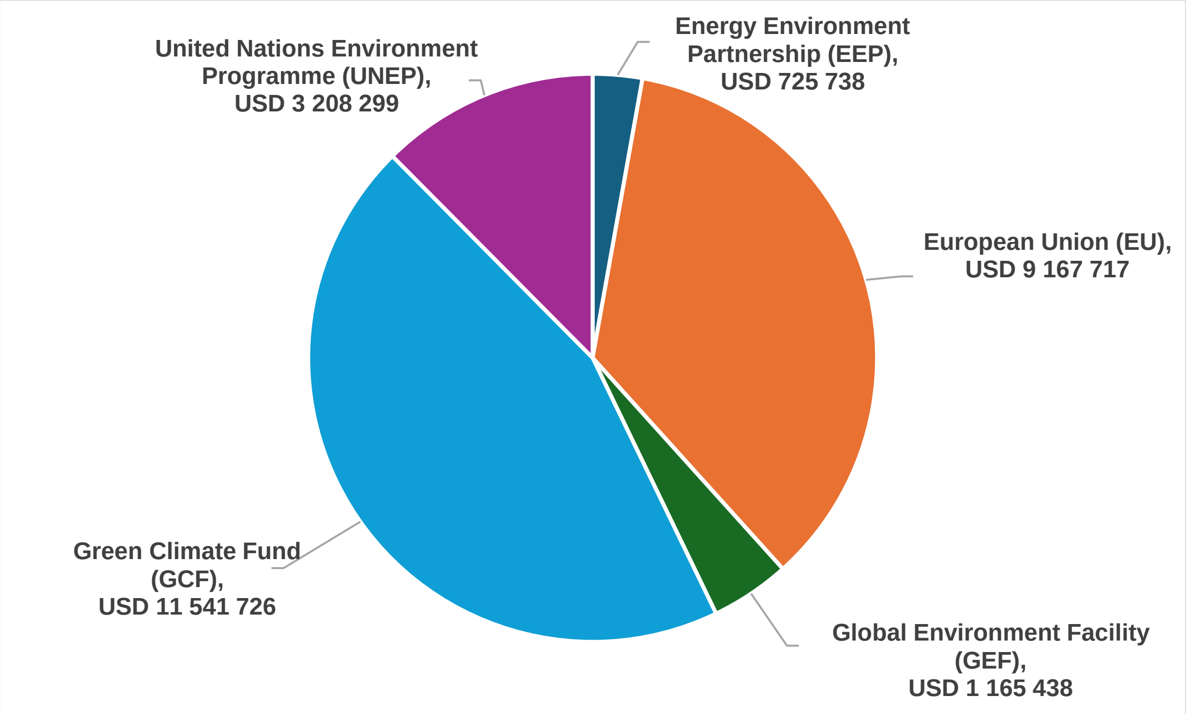

Figure 4.5: Percentage contribution of multilateral support per donor funder between 1 Jan 2021 – 31 Dec 2022

Table 4. 7. Multilateral funding split across financial instruments (USD)

Total 21-22	Grant	Loan	Equity
$ 25 808 919	$16 285 109	$ 5 000 000	$ 4 523 810

Table 4.8 and Table 4.9 provides further information on bilateral financial support and multilateral financial support committed between 1 Jan 2021 to 31 Dec 2022, respectively.

Table 4.8: Bilateral financial support committed between 1 Jan 2021 to 31 Dec 2022

Donor	**Title of activity, programme, project**	**ZAR**	**USD**	**Financial instrument**
Belgium	South African project on climate change adaptation in industries bearing fruit	41 880 720	2 679 834	Grant
Belgium	Strengthened adaptation capacity for a green and resilient economy in South Africa	4 879 243	279 608	Grant
European Union	JET-P South Africa Transnet Decarbonization FL	8 215 000 000	579 000 000	Loan
Finland	Circular Economy Incubator	1 570 527	100 494	Grant
Finland	Accelerating Circular Economy in Africa (ACE Africa)	3 315 557	212 154	Grant
Finland	The circular Economy Accelerator	4 345 125	278 033	Grant
France	Sovereign policy loan	4 929 000 000	347 400 000	Loan
France	Eskom loan	8 215 000 000	579 000 000	Loan
France	Transnet loan	3 286 000 000	231 600 000	Loan
Germany	Finance the near-term priority flagship programme and an IT-expert for the implementation of the climate change web-based monitoring and evaluation systems	5 549 632	355 106	Grant

Donor	Title of activity, programme, project	ZAR	USD	Financial instrument
Germany	Provide support to the coordination and implementation of the South African Ecosystem-based Adaptation Strategy	1 300 000	83 183	Grant
Germany	Climate Investment Funds	985 800 000	69 480 000	Grant
Germany	Integrated NDC Implementation Support in South Africa	59 969 500	4 226 700	Technical assistance
Germany	Supporting a South African Green Hydrogen Economy (H2 SA)	205 375 000	14 475 000	Technical assistance
Germany	Promotion of Green Hydrogen South Africa	410 750 000	28 950 000	Grant
Germany	Support to the Presidential Youth Employment Intervention	98 580 000	6 948 000	Technical assistance
Germany	Programme for Competencies and Employment	131 440 000	9 264 000	Grant
Germany	Innovative Financing of Green Infrastructure II	328 600 000	23 160 000	Grant
Germany	Skills for a Green and Just Energy Transition	164 300 000	11 580 000	Grant
Germany	Skills for a Green and Just Energy Transition	49 290 000	3 474 000	Grant
Germany	South African-German Energy Programme (SAGEN-4)	49 290 000	3 474 000	Technical assistance

Donor	Title of activity, programme, project	ZAR	USD	Financial instrument
Germany	Grid and System Integration of Variable Renewables II (SAGEN - Capacities 4 Energy Transition)	73 935 000	5 211 000	Technical assistance
Germany	Career Path Development for Employment (CPD4E)	106 795 000	7 527 000	Technical assistance
Germany	Promoting Green Hydrogen Economy - H2.SA	49 290 000	3 474 000	Technical assistance
Germany	Renewable Energy and Green Hydrogen Financing Facility (REGHF)	2 464 500 000	173 700 000	Loan
Germany	Climate-friendly and energy-efficient urban development in South Africa	1 971 600 000	138 960 000	Loan
Germany	Catalyst Research for Sustainable Kerosene (CARE-o-SENE)	657 200 000	46 320 000	Technical assistance
Germany	Greening the production and use of liquefied fuel gas in Southern Africa (Green-QUEST)	65 720 000	4 632 000	Technical assistance
Germany	Additional Grant Funding for JETP	492 900 000	34 740 000	Grant
Germany	Additional Funding for Komati Project	9 858 000	694 800	Grant
Germany	Renewable Energy and Green Hydrogen Financing Facility (REGHF) - TA	8 215 000	579 000	Grant
Switzerland	Global Eco-Industrial Parks Programme-South Africa country level intervention	11 825 911	677 691	Grant

Donor	Title of activity, programme, project	ZAR	USD	Financial instrument
UK	African Development Bank (Room to Run)	4 256 832 270	300 000 000	Loan
UK	UK Guarantee in support of JETP	14 189 440 900	1 000 000 000	Guarantee
UK	BII/PIDG Enabling higher risk private sector investment	7 094 720 450	500 000 000	Combination
USA	DFC support for JETP	14 189 440 900	1 000 000 000	Combination
USA	USTDA support for JETP	141 894 409	10 000 000	Grant
USA	USAID support for JETP	56 757 764	4 000 000	Technical assistance
USA	POWER AFRICA Southern Africa Energy Program	19 865 217	1 400 000	Technical assistance
USA	POWER AFRICA INVEST Program	7 804 192	550 000	Technical assistance
USA	Department of State support for JETP	8 513 665	600 000	Technical assistance

Table 4.9: Multilateral financial support committed between 1 Jan 2021 to 31 Dec 2022

Donor	Title of activity, programme, project	Implementing entity	ZAR	USD	Time frame		Financial instrument	Type of support	Sector
					Start date	End date			
EEP	Mustapha Energy: Converting Residual Waste in Cape Town	Nordic Development Fund (NDF) with funding from Austria, Finland and NDF. Project partners WOIMA Corporation Oy, Waste Mart, Waste Transformation 4 Energy Association, ENCHA & Mahube Infrastructure Fund, WDC	6 107 605	390 809	2021		Grant	Mitigation	Energy
EEP	Transforming water heaters into intelligent batteries	EEP is hosted and managed by the Nordic Development Fund (NDF) with funding from Austria, Finland and NDF	5 234 305	334 929	2021		Grant	Mitigation	Energy
EU	Improve the energy performance of government buildings	Deparment of Minerals and Energy in partnership with SANEDI.	60 000 000	3 839 238			Grant	Mitigation	Energy

Donor	Title of activity, programme, project	Implementing entity	ZAR	USD	Time frame		Financial instrument	Type of support	Sector
					Start date	End date			
EU	Achieve a net-zero energy wastewater treatment plants in South Africa (WWTP's)	The Project is implemented by Department of Minerals and Energy in partnership with SANEDI	60 000 000	3 839 238			Grant	Mitigation	Waste
EU	Facilitate empowering youth and women living in historically disadvantages communities to contribute towards the environmental protection, conservation, and sustainability		23 274 000	1 489 241			Grant	Adaptation	Cross-cutting
GEF	Accelerating cleantech innovation and entrepreneurship in SMEs to support the transition towards circular economy and create green jobs	UNIDO	8 258 201	528 420	03-Nov-21		Grant	Mitigation	Energy
GEF	Sustainable energy systems for urban-industrial development.	UNIDO	588 978	35 884	16-Aug-22		Grant	Mitigation	Energy
GEF	Promoting organic waste-to-energy and other low-carbon technologies in small and medium and micro-scale enterprises (SMMEs): Accelerating biogas market development	UNIDO	9 207 367	601 134	21-Mar-16	30-Nov-23	Grant	Mitigation	Cross-cutting

Donor	Title of activity, programme, project	Implementing entity	ZAR	USD	Time frame		Financial instrument	Type of support	Sector
					Start date	End date			
GCF	Climate Investor Two	FMO, the Dutch Development Bank	28 735 748	1 750 749	02-Dec-22	02-Apr-42	Grant	Cross-cutting	Cross-cutting
GCF	CRAFT - Catalytic Capital for First Private Investment Fund for Adaptation Technologies in Developing Countries	Pegasus Capital Advisors	54 711 333	3 333 333	27-Jan-22	27-Jan-34	Equity	Adaptation	Cross-cutting
GCF	Global Subnational Climate Fund (SnCF Global) - Equity	IUCN	17 670 000	1 190 476	20-Apr-21	20-Apr-40	Equity	Mitigation	Cross-cutting
GCF	Global Subnational Climate Fund (SnCF Global) – Technical Assistance (TA) Facility	IUCN	766 304	51 628	20-Apr-21	20-Apr-28	Grant	Mitigation	Cross-cutting
GCF	Blue Action Fund (BAF): GCF Ecosystem Based Adaptation Programme in the Western Indian Ocean	Blue Action Fund	975 432	65 718	09-Apr-21	09-Apr-28	Grant	Adaptation	Cross-cutting
GCF	Embedded Generation Investment Programme (EGIP)	DBSA	74 214 000	5 000 000	29-Jan-20	29-Jan-25	Loan	Mitigation	Energy
GCF	Pipeline development to deploy clean energy technology solutions in municipal wastewater treatment works of South Africa	UNIDO	2 459 088	149 822	31-Dec-21	26-May-24	Grant	Mitigation	Waste
UNEP	HCFC phase-out management plan (stage I)	UNIDO	19 484 767	1 256 516	03-Dec-12	31-Dec-23	Grant	Mitigation	IPPU

Donor	Title of activity, programme, project	Implementing entity	ZAR	USD	Time frame		Financial instrument	Type of support	Sector
					Start date	End date			
UNEP	HCFC phase-out management plan (stage II)	UNIDO	664 088	44 262	01-Jan-19	31-Dec-31	Grant	Mitigation	IPPU
UNEP	Preparation of an HFC phase-down plan	UNIDO	12 646 571	775 301	24-Sep-21	31-Dec-23	Grant	Mitigation	IPPU
UNEP	Support for transitioning from conventional plastics to more environmentally sustainable alternatives	UNIDO	17 401 837	1 132 220	15-Jun-19	31-May-23	Grant	Mitigation	Cross-cutting

4.1.2. Domestic support received

The South Africa Government continues to play a vital role in creating the conditions for inclusive economic growth and development and in establishing the appropriate economic framework to encourage and facilitate the shift to environmentally cleaner technologies and low carbon activities in the country. At national level there are a number of government departments that are integrating and mainstreaming climate change into sector plans.

National Treasury (NT) is responsible for managing South Africa’s national government finances. One of the initiatives undertaken by NT is mapping domestic climate finance. The need for this initiative was as a result of the lack of an existing central repository of climate-relevant expenditure data, as well as the pending Institutionalisation of a climate budget tagging (CBT) system across the three spheres of government. The CBT system is outlined in Section 4.1.1. of this chapter. Further to that, the existing system does not account for ODA and some bilateral/ multilateral funding and there is no existing typology or reference list for identifying and classifying climate-relevant expenditure or activities, therefore no standard climate relevant assessment model existed.

Using data and information received from the NT’s Public Finance Department, it is reported that in the financial years 2021/2022 and 2022/2023, there was approximately R 10 billion of domestic climate finance inflows, complementary to bilateral and multilateral financial support. Table 4.10 shows the aggregated domestic climate finance across various categories (Note: Data excludes local government spending and excludes administrative, policy and sectoral oversight). Spending supports mitigation programmes and activities classified under the energy sector, supporting the energy sector reforms; recapitalisation of Eskom spending is excluded since it was not possible to provide the disaggregated info on the recapitalisation to Eskom in terms of activities specifically related to climate change (e.g., related to the just energy transition). Spending which supported the AFOLU-related sectors includes the Expanded

Public Works Programme (EPWP), biodiversity and conservation, human settlements, water and irrigation. Grants directly related to the category of climate change and resilience included grants associated with flood management, disaster relief and environmental protection.

Table 4.10: Aggregated domestic climate finance for 2021/2022 and 2022/2023 (Source: National Treasury)

Category	Description	Fund description	National/ Provincial	Expenditure (R'000)		
				Financial Year		Grand Total
				2021/2022	2022/2023	
Energy	Emissions, transport, carbon, renewables and efficiency	ENRGY EF DMND SID MAN GRANT-MUNIC	National Departments	220 874	223 204	444 078
AFOLU	Agriculture, forestry, and other land use e.g. EPWP, biodiversity and conservation, human settlements, water and irrigation	DISASTER RESPNS HUM SET DEV GRANT	KwaZulu-Natal	0	3 852	3 852
		EPWP INCENTIVE: WORKING FORSTERY	National Departments	12 478	53 265	65 744
		EPWP:ENVIRONM PROTECT&INFRA PROG	National Departments	1 422 443	2 769 193	4 191 636
		WASTE MANAGEMENT	Free State	1 757	1 081	2 838
Climate and resilience	Climate resilience, disaster risk reduction and management, air quality	AGRICULTURE DISASTER MANAGEMENT	Free State	4 940	8 810	13 751
		DEELPAN DISASTER RELIEF FUND	North West	0	2 730	2 730
		DISASTER RESPNS HUM SET DEV GRANT	KwaZulu-Natal	0	4 812	4 812
		DISASTER RESPONSE FUNDS	KwaZulu-Natal	0	328 138	328 138
		DISASTER RESPONSE FUNDS	National Departments	0	140 003	140 003
		EPWP:ENVIRONM PROTECT&INFRA PROG	National Departments	41 979	35 954	77 933
		INT FUNDING FAC FOR CLIMATE IMMU	National Departments	15 564	18 030	33 594
		MUNICIPAL DISASTER GRANT	National Departments	378 371	0	378 371
		MUNICIPAL DISASTER RECOVERY GRANT	National Departments	0	3 318 741	3 318 741

Category	Description	Fund description	National/ Provincial	Expenditure (R'000)		
				Financial Year		Grand Total
				2021/2022	2022/2023	
		MUNICIPAL DISASTER RESPONSE GRANT	National Departments	0	516 661	516 661
		PROVINCIAL DISASTER GRANT	Limpopo	13 582	0	13 582
		PROVINCIAL DISASTER RELIEF GRANT	North West	971	9 956	10 928
Waste	Solid waste, waste water treatment, biological treatment, hazardous waste	WASTE BUREAU TYRE RECYCL INI:OPS	National Departments	263 110	265 294	528 403
Grand Total				**2 376 070**	**7 699 724**	**10 075 795**

4.2. Technology development and transfer support needed

4.2.1. Just Energy Transition

A just transition is at the core of implementing climate action in South Africa, as detailed in both the mitigation and adaptation goals described in the country's revised Nationally Determined Contribution (NDC). As part of ensuring a just transition, measures need to be put in place that plan for workforce reskilling and job absorption, social protection and livelihood creation, incentivising new green sectors of our economy, diversifying coal dependent regional economies and developing labour and social plans as and when ageing coal-fired power plants and associated coal production infrastructure are decommissioned (RSA, 2021). Similar measures are also necessary to adapt to the impacts of climate change.

The Presidential Climate Commission (PCC), established in 2020 to oversee and facilitate a just transition to a low-emissions and climate-resilient economy, adopted the Just Transition Framework in August 2022. The framework lays out a shared vision for shifting to an equitable, zero-carbon economy and identifies key policy areas and principles to achieve this. The Just Transition framework initially focused on four sectors and value chains that are at-risk in the transition, which form part of the formal economy: (1) the coal value chain, (2) the auto value chain, (3) agriculture and (4) tourism, as a first illustration of these risks.

South Africa highlighted various technologies in the country's first NDC that could help the country to further reduce emissions. These technologies included: energy efficient lighting; variable speed drives and efficient motors; energy efficient appliances; solar water heaters; electric and hybrid electric vehicles; solar PV; wind power; carbon capture and sequestration; and advanced bio-energy (RSA, 2016). Since the just transition in South Africa will require international co-operation and support, the revision of the NDC (RSA, 2021) provided an update on the support the country needed in addition to these technologies. Section 4.3 Financial Support Needed highlighted the investments needed in three priority sectors: electricity, New Energy Vehicles (NEVs), and Green Hydrogen (GH_2), specifically, investment needed in our electricity transmission and distribution networks and dramatically expanding renewable energy generation, investment in local production of green hydrogen and electric vehicles, and investing in local economies to develop skills and enable economic diversification.

4.2.2. New Energy Vehicles

Globally, technological developments are notably enabling the diversification of drivetrains, away from traditional internal combustion engines (ICE) towards electric and other alternative motors. While electric vehicles (EVs) still account for a marginal share of global vehicle sales, the shift is evident in leading markets. However, South Africa lags behind this global trend, and EVs remain extremely marginal, be it from an offer, demand or manufacturing perspective (TIPS, 2020). South Africa's ambition is to rapidly enter this space. In the New Energy Vehicle (NEV) sector, the focus of the JET IP is on transitioning the automotive sector value chains as the global shift to electric vehicle production gains momentum, building NEV supply chain localisation, and setting the base for NEV manufacturing and component manufacturing, to protect sector employment and promote new growth in sustainable manufacturing (PCC, 2022).

The country's Green Transport Strategy sets out government's vision to radically grow the uptake of EVs in South Africa. The Electric Vehicle White Paper (DTIC, 2023) outlines a comprehensive electric vehicle roadmap for South Africa and the structure of a suite of policy interventions tailored to the automotive industry. The White Paper sets out the policy goals and actions which will be taken to support the transition towards a broader new energy vehicle production and consumption in South Africa, with an immediate focus on electric vehicles. The White Paper is the culmination of substantial research and engagement to chart a viable and sustainable transition path for the industry, and follows the publication of a Green Paper in 2021, extensive industry consultation (assemblers, component makers and organised labour), consideration of public comments, all of which helped to shape the policy actions to be taken. The White Paper also builds on the work of the South African Automotive Masterplan (SAAM 2035), which was published in 2018 with the ambition of increasing productive output and deepening localisation across the value chain.

Key barriers in the NEV sector also relate to lack of a coherent policy environment for public transportation in South Africa, high upfront costs; concerns around scalability; lower flexibility and limited operational experience; delayed procurement decisions (due to expected technology cost declines); changing electricity tariffs and grid stability concerns; the lack of a hydrogen refuelling network; and the lack of charging/refuelling infrastructure standardisation. There is furthermore no electric mini-bus taxis (e-MBT) currently available in South Africa (TIPS, 2020). Active policies and measures are needed to improve the EV offering and stimulate demand, as well as incentives in the South African market to support the demand for EVs. The 2024 Budget Review by National Treasury has proposed incentivising local electric vehicle production to encourage the production of electric vehicles in South Africa, and it is proposed that an investment allowance be made available for new investments from 1 March 2026. Producers will be able to claim 150 percent of qualifying investment spending on production capacity for electric and hydrogen-powered vehicles in the first year of investment (NT, 2024).

On the manufacturing side, the issues revolve around developing the local EV value chain, and this ranges from the mining and beneficiation of minerals to the manufacturing of parts and components, to the manufacturing of vehicles. Complementing vehicle manufacturing, the local components industry plays a crucial role in South Africa's automotive value chain, even though local content levels are relatively low (TIPS, 2020). EVs have several unique components (primarily batteries, fuel cells and electric powertrains). In turn, some components, such as engine parts, radiators and catalytic converters are replaced in two battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs). While Lithium-Ion Batteries (LIBs) are currently imported, South Africa has committed to manufacturing LIBs, and efforts are being made by the public and private sector to further promote the manufacturing of LIBs in South Africa. South Africa is also well-endowed in an array of key EV-related minerals.

4.2.3. Hydrogen-related technologies

Hydrogen and its application in various sectors have the potential to reduce emissions and create jobs in its various value chains, which could be used to support the just transition in South Africa (DSI, 2022). New technologies such as green hydrogen are expected to play an important role in SA's low-carbon transition, but some of these technologies still require active support to reach commercial use. While SA is well positioned to benefit from the future economy, the sector is still at an early development stage, and several aspects remain relatively uncertain, including technology options, costs, and the specific role of the public sector. Harnessing the requisite investment to unlock this market will require meaningful stakeholder coordination and the creation of an enabling environment (World Bank Group, 2022).

The DSI had identified hydrogen fuel-cell technologies (HFCT) for their potential to reduce emissions and secure the country's energy future. As well as producing power, fuel cells also produce heat as a by-product. This heat can be exploited by customising fuel cells for use as a Combined Heat and Power (CHP) source and supply decentralised power and heating for buildings and industries. The South African government is driving the R&D on HFCT and related technologies for three main reasons *viz*.:

- South Africa is home to 75% of the global reserves for PGMs and most are used as value-added materials or catalysts in HFCT (DSI, 2022). This provides great potential for socio-economic benefits to be obtained from these natural resources due to the increased global demand for PGM products.
- The Human Capital Development (HCD) required to develop this sector will lead to job creation in South Africa – in order to supply the rest of the world with a much needed resource.
- R&D of HFCT as a viable alternative, renewable energy source is essential to reduce CO_2 and GHG emissions and help meet the country's commitment to the global targets.

The Hydrogen South Africa (HySA) Research, Development and Innovation (RDI) Strategy was approved by Cabinet in 2007 and officially launched in 2008 by the then Department of Science, Technology and Innovation (now the Department of Science and Innovation (DSI)). The objective of 15-year HySA Programme was to develop the hydrogen economy, with a focus on beneficiation of Platinum-group metals (PGMs) through the development of HCFT.

The development of the Hydrogen Society Roadmap (HSRM) was initiated in 2020 and an Interdepartmental Committee developed the terms of reference for the development of the HSRM. The HSRM was published in February 2022 by the DSI and serves as a national coordinating framework to facilitate the integration of hydrogen-related technologies in various sectors of the South African economy and stimulate economic recovery, in line with the Economic Reconstruction and Recovery Plan (DSI, 2022). The HSRM sets national ambitions and sector prioritisation on the deployment of the hydrogen economy in South Africa, in line with the Integrated Energy Plan.

A proposed South African Green Hydrogen (GH_2) Commercialisation Strategy (GHGS) was released for public comment in December 2022. The GHGS builds on the strong foundation of work done by the DSI with respect to its HySA programme and the Hydrogen Society Road Map. A Green Hydrogen Commercialisation Panel was established in June 2021 by the Minister of Trade, Industry and Competition. The panel consists of private and public sector champions in the potential green hydrogen value chain and is currently being co-ordinated by the Industrial Development Corporation of South Africa (IDC). The purpose of the panel was to specifically focus on the development of a South African Green Hydrogen Commercialisation Strategy and Action Plan. The successful implementation of the Green Hydrogen commercialisation strategy will depend on the execution of the six key elements (DTIC, 2022) outlined in Table 4.11.

Table 4. 11 Overview of the six key elements in the Green Hydrogen Commercialisation Strategy (DTIC, 2022)

Key Element	**Description**
1. Prioritise exports	Target exports of green hydrogen and green chemicals by leveraging on South Africa's proprietary Fischer Tropsch technology and utilising financing support mechanisms including grants, concessional debt and contract for difference / price subsidies to improve the financial viability of these projects.

Key Element	Description
2. Stimulate domestic markets	In parallel to the export strategy, develop projects along the value chain to stimulate demand for green hydrogen in South Africa. "Low hanging fruit" opportunities to be prioritised to provide confidence in the domestic market. Examples include green steel, hydrogen valley mobility programme and sustainable aviation fuel projects.
3. Support localisation	Develop local industrial capability to produce fuel cells, electrolyser, ammonia cracking and balance of plant equipment and components by leveraging on South Africa's PGM resources. Together with demand stimulation this will drive longer term GH_2 price reduction allowing penetration in various sectors.
4. Secure financing	"Crowd in" and secure funding from various sources and in various forms including grants, concessional debt and contract for differences.
5. Proactive socio-economic development	Maximise development impact (incl. skills and economic development and social inclusion); ensure gender equality, BBBEE and community participation; maximise job creation and alternative options for potential job losses.
6. Role of government in policy and regulatory support	Position GH_2 as a key early contributor to decarbonization and a just transition in the country programme of work being collated by the JET-IP Task Team ensuring a fair proportion of climate finance is sourced to enable development of this industry. Prioritize the execution of the green hydrogen commercialisation strategy and the development of a national GH_2 infrastructure plan. Drive the required policy and regulatory changes required to sustain long term growth of the new hydrogen industry. Mobilise and coordinate the Government support required to support the development of this new industry for South Africa.

The costs associated with the development of the Hydrogen Economy are summarised below. The estimates below are high level and will be validated by a comprehensive study (DTIC, 2022):

i. There will be a need for funding from development finance institutions (DFIs) in the form of grants, project development funds or concessional debt facilities. It is estimated that DFIs will need to contribute about R180bn in equity and R400bn in debt at concessional rates by 2050.

ii. Capex funding requirement from private sector. It is estimated that the private sector will need to contribute about R410bn in equity and would need to source a further R956bn in debt from commercial banks.

iii. Government subsidies and incentives will be required to support the catalytic hydrogen projects by the introduction of supportive policies and a regulatory framework for GH_2 that aids GH_2 price parity to increase domestic GH_2 demand.

iv. Costs associated with changes / new regulations and policies.

v. R&D spending to stay ahead of innovation and technology and remain competitive (amount still to be determined).

vi. Gradual reduction in income from petrochemical levies (impact to the economy still to be determined).

vii. Development of state procurement programme/s.

viii. Costs to develop hydrogen infrastructure.

ix. Cost associated with establishing global partnerships and bilateral government to government agreements.

x. Costs to develop training and skills development programmes to support job creation within the GH_2 sector.

4.3. Technology development and transfer support received

4.3.1. Green Technologies Stocktake

A ‘Green Technologies Stocktake’ study in support of achieving a just transition to a low carbon and climate resilient economy and society was commissioned by the Technology Innovation Agency (TIA) in 2024. The project aimed to undertake a technology readiness and capability stocktake to identify mature or near-market green technologies developed in South Africa that are ready for deployment into local supply chains, and/ or mature technologies developed internationally that can be localised in South Africa and deployed into local supply chains.

The study comprised two phases:

- Phase one consists of mapping the current low-carbon and climate-resilient technologies landscape in South Africa to identify gaps and opportunities; identifying those technologies in the research and development phase that are at an advanced stage for commercialisation and localisation; and investigating the readiness of low-carbon and climate resilient technologies in the energy and transport sectors for responding to the transition.
- In Phase two, the work would assess the country’s capabilities to deploy low-carbon and climate resilient technologies in the economic sectors and their ability to attract finance at various scales.

The project is ongoing and results of which will be communicated in subsequent BTRs.

4.4. Capacity-building support needed

4.4.1. Capacity needs for Climate Budget Tagging

There are many capacities that should be developed for Climate Budget Tagging, these include priorities such as (NT, 2022b):

- Establishing the governance structures and appointing or designating standing human resource capacities in the secretariat and helpdesk functions. The National Treasury and its key partners, the DFFE and DPME, should consider that extent to which national Technical Task Team (TTT) membership would be a full-time job in the initial years when appointing individuals to this role;
- Developing the core human resource capacities through training for CBT, i.e. in the NT, members of the different governance structures etc. (training will cover topics such as climate change relevance; identification of climate benefits; improved tagging consistency; etc.);
- Developing the system capacities to manage CBT in budget systems (submission and public financial management systems).
- There is a need for standing CBT training capacity, as CBT rolls out, to develop knowledge on climate change and capacities to implement the CBT methodology in departments of national and provincial government and municipalities. There is also a need for training programmes for institutions as they come onto the system.

4.4.2. Capacity needs for Just Energy Transition (JET) Skills Implementation Plan

The overarching goal of the JET skills implementation plan is to contribute to building a well co-ordinated, responsive, resourced, and effectively functioning skills ecosystem. This skills ecosystem will include communities, business, government, and other institutions to ensure that South Africa has an employable, skilled, and capable workforce to implement the JET and support economic growth in the core value chains (PCC, 2023). Several challenges within the skills sector that must be overcome for South Africa to deliver on the JET were outlined in the JET implementation plan (PCC, 2023). Based on these challenges, the following needs were identified:

- A centralised, coherently organised co-ordination for skills development for the JET – There is a need to establish a co-ordination mechanism for the national planning and development of sustainability skills in South Africa.

- A coherent national picture of supply and demand of JET skills - fragmentation has resulted in many small studies on skills supply and demand, and it is not possible to aggregate information or data to build a clear national picture of supply and demand of JET due to differing methodologies used.
- Skills anticipation systems – development and implementation of frameworks for skills anticipation for employers
- Better insight of factors shaping skill formation systems at a national level - the object of analysis is education and training at a systemic level, including workplace-based and informal learning, and its interaction with economic and social institutions.
- Disconnect between training institutions and specific needs of local communities in the context of clean energy – A concerted effort is needed to bridge the gap between training institutions and communities, ensuring that skills development is inclusive, relevant, and accessible to all, thereby fostering a JET in South Africa.

4.4.3. Capacity needs for Gender Climate Mainstreaming

Adoption and implementation of gender-climate mainstreaming will require capacity building and awareness raising to ensure that it reaches all spheres and levels of the public and private sectors in South Africa. Transformational change will not be achieved with a single training event, or awareness-raising programme, and a long-term plan is needed. One of the strategic actions proposed in South Africa's draft Gender Action Plan (DFFE, 2022), Strategic Action 6, is to 'Implement a gender awareness raising and capacity building programme'.

Activities needed to support this programme are (DFFE, 2022):

i) A gender-climate mainstreamed cost-benefit analysis should be undertaken that deepens and contextualises available research on the direct benefits of women-led and inclusive climate change responses across sectors and societal systems, and in addition, enumerates the gendered co-benefits of climate change responses. The results of this analysis will be used to inform capacity building and awareness raising at different levels.

ii) A programmatic gender–climate education and awareness raising campaign should be designed to be implemented across sectors, systems and society. Integrating the results of the cost benefit analysis — among other resources. This campaign will be complimented by a parallel five-year capacity building and awareness raising programme which will also conduct continuous and formative monitoring and evaluation, applying gender-sensitive indicators.

iii) Capacity building programmes are needed across all NDC sectors and government, to support and capacitate officials responsible for implementing gender-climate mainstreaming activities — including the GFPs. This will also be key to supporting the achievement of their future Key Performance Indicators for gender and climate change. These officials should be encouraged to take ownership of in-house gender-climate mainstreamed activities — including ongoing capacity building and awareness raising in their departments.

4.5. Capacity-building support received

Technical and capacity building support received from developed countries that commenced in the 1 Jan 2021-31 Dec 2022 reporting period is summarised in Table 4.5; and is additional to the support that was reported in Table 4.12 of BUR-5.

Table 4. 12. Capacity training received (Source: DFFE)

Title of activity, programme, project or other	Programme/project description	Time frame	Recipient entity	Implementing entity	Type of support	Sector	Use, impact and estimated results
Climate Vulnerability and adaptation assessment	Assessment is intended to aid non-Annex I Parties in selecting their V&A assessment approaches, methods and tools, by providing as wide a range of methods and tools as possible.	Apr-21	DFFE	UNEP/UNDP Global Support Programme	Adaptation	Cross-cutting	Improve understanding to aid non-Annex I Parties in selecting their V&A assessment approaches, methods and tools, by providing as wide a range of methods and tools as possible.
Greenhouse Gas (GHG) Management Institute 501 IPCC: Introduction to Crosscutting issues	This course is a rigorous introduction to the Institute's series on greenhouse gas inventories using the 2006 IPCC Guidelines.	Oct 2021 - Mar 2022	DFFE	UNFCCC	Mitigation	Cross-cutting	Improved understanding of the fundamental processes and techniques for compiling an inventory of GHG emissions and removals before you learn to estimate emissions and removals from specific sectors and activities in the other courses in this series.
GHG Management Institute Proficiency Certificate 551 IPCC: Waste	This course provides a rigorous training on the emission sources and estimation methodologies for the waste sector based on the internationally endorsed 2006 IPCC Guidelines.	Oct 2021 - Mar 2022	DFFE	UNFCCC	Mitigation	Waste	Improved understanding of expert level knowledge and skills necessary to use and or prepare GHG emission estimates from waste-related emission sources.
GHG Management Institute 511 IPCC Guidelines: Energy Sector	This course provides a rigorous training on the emission sources and estimation methodologies for the energy sector based on the internationally endorsed 2006 IPCC Guidelines.	Oct 2021 - Mar 2022	DFFE	UNFCCC	Mitigation	Energy	Improved understanding of expert level knowledge and skills necessary to use and or prepare GHG emission estimates from energy-related emission sources.

Title of activity, programme, project or other	Programme/project description	Time frame	Recipient entity	Implementing entity	Type of support	Sector	Use, impact and estimated results
GHG Management Institute 541 IPCC Guidelines: Forestry and Other Land Uses	This course provides a rigorous training on the emission sources and removal sinks and estimation methodologies for the forestry and other land use sector based on the internationally endorsed 2006 IPCC Guidelines.	Oct 2021 - Mar 2022	DFFE	UNFCCC	Mitigation	Forestry and Other Land Uses	Improved understanding of expert level knowledge and skills necessary to use and or prepare GHG emission estimates from Forestry and Other Land Uses-related emission sources.
GHG Management Institute 521 IPCC Guidelines: Industrial Processes and Product Use	This course provides a rigorous training on the emission sources and estimation methodologies for the industrial processes and other product use sector based on the internationally endorsed 2006 IPCC Guidelines.	Oct 2021 - Mar 2022	DFFE	UNFCCC	Mitigation	Industrial Processes and Product Use	Improved understanding of expert level knowledge and skills necessary to use and or prepare GHG emission estimates from Industrial Processes and Product Use-related emission sources.
Greenhouse Gas (GHG) Management Institute 501 IPCC: Introduction to Crosscutting issues	This course is a rigorous introduction to the Institute's series on greenhouse gas inventories using the 2006 IPCC Guidelines.	Nov 2022 - Jun 2023	DFFE	UNFCCC	Mitigation	Cross-cutting	Improved understanding of the fundamental processes and techniques for compiling an inventory of GHG emissions and removals before you learn to estimate emissions and removals from specific sectors and activities in the other courses in this series.
GHG Management Institute Proficiency Certificate 551 IPCC: Waste	This course provides a rigorous training on the emission sources and estimation methodologies for the waste sector based on the internationally endorsed 2006 IPCC Guidelines.	Nov 2022 - Jun 2023	DFFE	UNFCCC	Mitigation	Waste	Improved understanding of expert level knowledge and skills necessary to use and or prepare GHG emission estimates from waste-related emission sources.

Title of activity, programme, project or other	Programme/project description	Time frame	Recipient entity	Implementing entity	Type of support	Sector	Use, impact and estimated results
GHG Management Institute 511 IPCC Guidelines: Energy Sector	This course provides a rigorous training on the emission sources and estimation methodologies for the energy sector based on the internationally endorsed 2006 IPCC Guidelines.	Nov 2022 - Jun 2023	DFFE	UNFCCC	Mitigation	Energy	Improved understanding of expert level knowledge and skills necessary to use and or prepare GHG emission estimates from energy-related emission sources.
GHG Management Institute 541 IPCC Guidelines: Forestry and Other Land Uses	This course provides a rigorous training on the emission sources and removal sinks and estimation methodologies for the forestry and other land use sector based on the internationally endorsed 2006 IPCC Guidelines.	Nov 2022 - Jun 2023	DFFE	UNFCCC	Mitigation	Forestry and Other Land Uses	Improved understanding of expert level knowledge and skills necessary to use and or prepare GHG emission estimates from Forestry and Other Land Uses-related emission sources.
GHG Management Institute 521 IPCC Guidelines: Industrial Processes and Product Use	This course provides a rigorous training on the emission sources and estimation methodologies for the industrial processes and other product use sector based on the internationally endorsed 2006 IPCC Guidelines.	Nov 2022 - Jun 2023	DFFE	UNFCCC	Mitigation	Industrial Processes and Product Use	Improved understanding of expert level knowledge and skills necessary to use and or prepare GHG emission estimates from Industrial Processes and Product Use-related emission sources.
GHG Management Institute 531 IPCC Guidelines: Agriculture Sector	This course provides a rigorous training on the emission sources and estimation methodologies for the agriculture sector based on the internationally endorsed 2006 IPCC Guidelines.	Nov 2022 - Jun 2023	DFFE	UNCCCC	Mitigation	Agriculture	Improved understanding of expert level knowledge and skills necessary to use and or prepare GHG emission estimates from Agriculture sector-related emission sources.

Title of activity, programme, project or other	Programme/project description	Time frame	Recipient entity	Implementing entity	Type of support	Sector	Use, impact and estimated results
Consultative Group of Experts (CGE) African Training Workshop on Tracking of NDCs, Bonn Germany	Enhance the technical capacity of experts from developing country Parties in establishing or building upon the understanding and application of the reporting provisions relevant for the tracking of progress of NDCs, including identifying indicators, as well as for the support needed and received in relation to tracking progress of NDCs.	Dec-22	DFFE	UNFCCC	Cross-cutting	Cross-cutting	Improve understanding of existing MRV arrangements and the ETF by acquiring knowledge of the key components involved in tracking NDC progress, including the support needed and received, main stakeholders, and data ownership. Additionally, it is important to understand how to compile relevant information and establish sustainable institutional arrangements for tracking NDCs

4.6. Support needed and received for the implementation of Article 13 of the Paris Agreement and transparency-related activities, including for transparency-related capacity-building

4.6.1. Strengthening South Africa's capacity to comply with the Enhanced Transparency Framework (ETF) requirements under Article 13 of the Paris Agreement

South Africa received multilateral financial support from the Global Environment Facility (GEF) as part of the Capacity Building Initiative for Transparency (CBIT) Project for South Africa. An overview of project details is provided in Table 4.13.

Table 4. 13. Support received for the implementation of Article 13 of the Paris Agreement – CBIT (Source: DFFE)

Project Title: Strengthening South Africa's capacity to comply with the Enhanced Transparency Framework (ETF) requirements under Article 13 of the Paris Agreement	
Country	South Africa
GEF Agency	United Nations Environment Programme
Executing Partner	The Department of Forestry, Fisheries and the Environment
GEF Focal Area	Climate Change
Submission date	20 June 2018
Project implementation start date	01 June 2019
Project Duration (Months)	66
GEF Project Financing	USD 1,100,000
Co-financing	USD 1,018,969 from the DFFE (SA Government)

Project End Date	31 December 2024

The objective of the project is 'To enhance human and institutional capacity related to the enhanced transparency framework in South Africa such that South Africa will be able to meet the enhanced transparency framework requirements under the Paris Agreement'. Project outputs include:

- An institutional arrangement that supports operationalization of South Africa's Climate Change Monitoring & Evaluation (M&E) System established.
- Long-term strategy on GHG inventory compilation and mitigation actions' assessment developed.
- Relevant entities trained on international MRV guidance as well as the ETF.
- South Africa having built a sufficient Roster of Experts to participate in the ETF reviews.

The total amount of GEF funding received was USD 1 100 000. The CBIT project falls under GEF's support for convention-related reporting and assessment, and is implemented on an agreed full cost basis requiring only in-kind contribution by GEF-eligible countries. For this project, the confirmed co-financing at CEO endorsement phase totals USD 1 018 969. This amount has been included as part of the overall funding received from the GEF.

Table 4.14. provides an overview of the CBIT project's objectives, expected outcomes and achieved outcomes, noting that while information on the training received is out of the reporting period for the SABTR1, it is meant to highlight the country's progress towards preparing for the BTR reporting considering modalities, provisions, and guidelines for the Enhanced Transparency Framework.

Table 4. 14. The Capacity Building Initiative for Transparency project objectives, expected outcomes and achieved outcomes to date

Description	Expected outcomes	Achieved outcomes to date
Technical Expert in Greenhouse Gas Inventory information systems	Hiring of a technical expert in GHG inventory to provide expertise in GHG inventory within the DFFE.	The service provider has been hired for the provision of greenhouse gas inventory expertise within the DFFE in the GHG Inventory Directorate and the Inception meeting was held on 30 May 2023. The service provider consists of Project leader, Project manager and a Junior consultant. The service provider provides support on the implementation of the requirements of the Enhanced Transparency Framework(ETF), with regards to the National Inventory Report (NIR) for all the IPCC sectors. Supports the DFFE in updating the National GHG Emissions Inventory data on the National GHG Inventory Management System. Provides training for DFFE officials and other data providers on GHG Inventory compilation and GHG tools.
Regional Adaptation Workshops	Organising of 15 M&E System information management system training workshops for Adaptation	The total number of workshops organized to date is 17 across the different provinces of South Africa. The workshops focused on engaging the province and building their capacities on the use of the National climate Change Information System to provide the DFFE with data on adaptation. Furthermore, the workshops also focussed on capacitating provinces on how they can develop their own provincial climate change information systems as

Description	Expected outcomes	Achieved outcomes to date
		well as provincial climate change databases that can be linked to national ones to support monitoring and evaluation as well as reporting under the ETF. There were also workshops on Indigenous Knowledge Systems and how data from that can be obtained for reporting under the ETF.
Gender differentiation and equality in climate change workshops	Organising of gender differentiation workshops in climate change.	Activity completed. South Africa has organised 2 workshops on Gender differentiation and equality in climate change. However, the Directorate Climate Change Development and International Mechanisms anticipates on supporting the Directorate: United Nations Framework Convention on Climate Change with organizing a gender mainstreaming workshop in 2023.
Peer to peer exchange for international experts to share knowledge and experiences at DFFE.	Organising of peer-to-peer exchange for international experts to share knowledge and experiences on implementation of the MRV framework as well as preparation for the ETF	South Africa, through the DFFE has visited the USA September 2023 and Canada in February 2024. These visits were for the DFFE officials to learn from developed countries on how they developed and maintained as well as used their climate change monitoring and evaluation systems as well as institutional arrangements for international reporting on climate action. This is imperative as South Africa's enhances its monitoring and evaluation system as well as institutional arrangements to align with the reporting under the enhanced transparency framework. The DFFE has also done a peer-to-peer exchange with the UK in August 2024. South Africa, through the DFFE has also hosted other African countries for the peer-peer workshop that organised in March 2024 in Pretoria to learn the same. The visiting countries were Kenya, Namibia, Malawi, Ghana, Gambia, and Zambia.

Description	Expected outcomes	Achieved outcomes to date
A consortium of experts to support the long-term capacity building strategy on GHG inventory compilation and mitigation actions' assessment	Hiring of a consortium of experts to support the long-term capacity building strategy on GHG inventory and mitigation actions at national and provincial level.	A service provider has been hired to develop the long-term capacity building strategy. The strategy also included the development of training program on Greenhouse Gas Inventory compilation and Mitigation Actions' assessment. A hands-on training course was developed and offered for GHG Inventory compilation focussing on the general overview, and the four IPCC sectors including Energy, IPPU, AFOLU and Waste. It was offered to 30 officials from national government departments with cross cutting mandates on climate change as well as data providers such as the Agricultural research Council. A hands-on training course was developed and offered for mitigation actions' assessment compilation focussing on the general overview, and the four IPCC sectors including Energy, IPPU, AFOLU and Waste. It was offered to 30 officials from national government departments with cross cutting mandates on climate change as well as data providers such as the Agricultural research Council.

4.6.2. GEF Expedited Enabling Activity "South Africa: Enabling Activities for the Preparation of Initial Biennial Transparency Report (BTR1) to the United Nations Framework Convention on Climate Change (UNFCCC)"

South Africa also received multilateral financial support from the GEF as part of GEF Expedited Enabling Activity (EEA) for South Africa for the preparation of its initial Biennial Transparency Report to the UNFCCC. An overview of project details is provided in Table 4.15.

Table 4. 15. Support received for the implementation of Article 13 of the Paris Agreement – GEF EEA (Source: DFFE)

Project Title: GEF Expedited Enabling Activity (EEA) "South Africa: Enabling Activities for the Preparation of Initial Biennial Transparency Report (SABTR1) to the UNFCCC"	
Country	South Africa
Executing Agency	SouthSouthNorth (SSN)
Executing Partner	The Department of Forestry, Fisheries and the Environment
GEF Focal Area	Climate Change
Submission Date:	April 2025
Project Duration (Months)	21 months
Project implementation Period	11 August 2023 to 30 April 2025*
GEF Project Financing	USD 600 000
Co-financing	In kind - DFFE

**Note: This funding for this project is not included in the section on international support received since it falls out of the 1 Jan 2021-31Dec 2022 reporting period for the BTR.*

The project aims to support the Republic of South Africa, through the Department of Forestry, Fisheries and Environment (DFFE), to prepare and submit its First Biennial Transparency Report (SABTR1) which complies with the UNFCCC and the Paris Agreement reporting requirements, while responding to its national development goals. The project is being implemented using the UNEP as the implementing agency of the GEF and the SSN is the executing agency on behalf of the South African Government (DFFE). The third-party modality was adopted in order to avoid bureaucratic processes often faced by the DFFE when implementing projects directly, thereby ending up causing delays in projects' implementation. This is part of the lessons learned from the previous implementation of other GEF-funded projects such the enabling activities projects and the 1st CBIT project. The project is being implement with full strategic and technical oversight by the DFFE. The CSIR has been procured to assist the DFFE to develop the SABTR1. The CSIR works with the entire Climate Change and Air Quality Branch to draft and finalize the BTR, though the work is coordinated and overseen under the International Climate Change Relations and Reporting Chief Directorate. The CSIR will also assist the DFFE with the electronic reporting including generating the Common Reporting Tables (CRTs) for the GHG Inventory as well as the Common Tabular Formats (CTFs) for the NDC tracking and Support needed and Received Chapters using the UNFCCC reporting tool. Furthermore, the University of Cape Town has been procured as the independent reviewers of SABTR1.The independent review will review compliancy with the MPGs in terms of both completeness and transparency and recommendations on what can be addressed in the first BTR well as in subsequent BTRs.

Project outputs include:

1. South Africa's First BTR prepared and submitted to UNFCCC by December 2024, and

2. Stocktaking report for preparation of the project proposal for subsequent reports under the UNFCCC and Paris Agreement completed.

The DFFE is providing in kind co-finance in the implementation of the BTR project. The Project Coordinator under the project receives an additional 37% of their salary from the DFFE as well as internet service and a mobile cellular device with airtime. Additionally, the extended Project Management Unit, from the International Relations and Reporting Chief Directorate is a permanent structure under the DFFE comprising the Deputy Director, the Director and the Chief Director.

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Annex 1: Methodologies and assumptions used to estimate the GHG emission reductions or removals due to each action, policy and measure

12L Tax Incentive Program

No direct calculations were made on the initial data provided by SANEDI. The $kgCO_2e$ savings for each project were supplied directly by SANEDI, reflecting the various energy carriers involved. The emission data sets from SANEDI are based on information submitted by claimants and verified by an accredited entity. The process starts with the creation and submission of a baseline benchmarking model and report to SANEDI for approval, which describes the business-as-usual scenario where the energy-saving measure would not have been implemented.

Integrated Demand Management (IDM) Programme

Emission savings ($MtCO_2e$) = activity data (GWh) x grid emission factor (tCO_2e/GWh).

The emission savings were determined by taking the activity data, which was provided by the Eskom IDM Department, and multiplying it by the appropriate grid emission factor. This grid emission factor is published annually by Eskom in their reports. It was assumed that the measures implemented up to 2018 would still be operational in 2022.

Municipal Energy Efficiency and Demand Side Management programme

Emission savings ($MtCO_2e$) = activity data (GWh) x grid emission factor (tCO_2e/GWh).

The emission reductions were determined by multiplying the activity data (a secondary dataset supplied by the Department of Environment, Forestry, and Fisheries) with the corresponding grid emission factor. The Department of Forestry, Fisheries, and the Environment provided aggregate data (in GWh) for the years 2011 to 2015. For the period 2015 to 2018, values were also given, but these were labeled as ‘expected savings.’ It was assumed that the measures continued, and the annual emission reductions from 2019 to 2022 were considered to be the same as those recorded for 2018.

The National Cleaner Production Centre South Africa (NCPC) program

The savings detailed in this report are derived from emission calculations performed by the NCPC. The NCPC determines the emission savings for each project based on the specific energy carrier involved. These emissions were aggregated and reported by the NCPC for each year the program has been active. It was assumed that the NCPC projects are ongoing and continue to save the same amount of MtCO2e as recorded in the last year (2020). It is also assumed that the savings from projects implemented during the program persist for a period of five years.

Private Sector Energy Efficiency (PSEE) Programme

Emission savings (MtCO2e) = activity data (GWh) x grid emission factor (tCO2e/GWh).

The calculations presented in this report utilize secondary data sets, specifically energy savings measured in GWh, sourced from the National Business Initiative’s report on the program’s outcomes. These activity data sets are then multiplied by the South African grid emission factor for the corresponding year, as determined from the Eskom annual report, to calculate the MtCO2e value. It is assumed that the projects initiated during the program are still operational to date.

Private sector embedded solar generation

Emission savings ($MtCO_2e$) = activity data (GWh) x grid emission factor (tCO_2e/GWh).

The calculations in this report are derived from secondary activity data sets, specifically new installed capacity additions in MW, which are converted to GWh. These data sets were obtained from the South Africa Solar PV Update Report by the Association for Renewable Energy Practitioners. A capacity factor of 15% for the solar PV panels and an operational time of 6 hours per day were assumed. These assumptions were used to estimate the annual electricity generation from the installed solar PV. This estimated generation was then multiplied by the grid emission factor, sourced from Eskom's annual reports, to determine the carbon emission reductions. It is assumed that the projects are still ongoing and continue to achieve the same $MtCO_2e$ savings as recorded in 2020.

Renewable Energy Independent Power Producer Procurement (REIPPP) programme

Emission savings ($MtCO_2e$) = activity data (GWh) x grid emission factor (tCO_2e/GWh)

Emission savings ($MtCO_2e$) = activity data (GWh) x grid emission factor (tCO_2e/GWh) The secondary activity data sets, which detail the electricity generated by renewable energy projects each year and are sourced from Eskom Integrated Annual Reports, are multiplied by the relevant annual grid emission factor to determine the emissions avoided through renewable energy generation. A conversion factor of 0.277778 was used to convert GJ to MWh, ensuring the coal emission factor is in the correct unit. A coal generation baseline was assumed. It is also assumed that these projects are still operational and continue to achieve the same $MtCO_2e$ savings as last recorded in 2020.

Natural Gas Fuel Switch Programmes

The total primary natural gas supply in the country was sourced from the Department of Mineral Resources and Energy's Energy Balance, available on the DMRE website. The emission savings were calculated as the difference between emissions from coal and natural gas. To determine these savings, the GJ of gas supplied was multiplied by the difference in emission factors for coal and natural gas. For the years 2017 to 2019, it was assumed that the energy balance figures were the same as in 2016, as the Department had not updated these figures. It is also assumed that these projects are still operational and continue to achieve the same MtCO2e savings as last calculated in 2020.

Bus Rapid Transport (BRT) System

Applied the ASIF approach (Eichhorst et al. 2018).

Weekday average BRT Passenger trips: MyCiti (2011-2019): 56023; GoGeorge (2016-2019): 12949; A Re Yeng (2016-2019): 6663; Libhongolethu (2017-2019): 9882; (Derived from (National Treasury, 2014; National Treasury, 2016; National Treasury, 2018; National Treasury, 2021))

Average trip length: 23 km (van Ryneveld, 2014) Modal Shift Car: 10%; Minibus-Taxi: 61%; Bus: 8% (DEA, 2016b) Occupancy: Car: 1.4; Minibus-Taxi:14 (Stone et al. 2018) BRT: 56 (derived from DEA, 2016b)

Fuel split of road transport modes (Stone et al. 2018): Car Gasoline: 96%; Car Diesel: 4%; Car Hybrid Gasoline: 0.02%; Minibus-Taxi Gasoline: 92%; Minibus-Taxi Diesel: 8%; Bus Diesel: 100%

It is also assumed that these projects are still operational and continue to achieve the same MtCO2e savings as last calculated in 2020.

Energy consumption factor (L/100km) of road transport (Stone et al. 2018): Car Gasoline: 7.8; Car Diesel: 7.4; Car Hybrid Gasoline: 6; Minibus-Taxi: Gasoline: 13.7; Minibus-Taxi Diesel: 12.7

Net calorific values per fuel type (MJ/l): Gasoline: 34.2; Diesel: 38.1 (DEA, 2018e)
Emission Factors for CO2 per fuel type (kg/TJ): Gasoline: 69300; Diesel: 74100 (IPCC, 2006) GWP (IPCC, 1996)

Average trip distance information of GoGeorge; A Re Yeng and Libhongolethu were not available. Modal shift information for GoGeorge; A Re Yeng and Libhongolethu were not available. The modal shift information for Rea Vaya BRT was used instead.

Transnet Road-to-Rail Programme

No calculations undertaken as the emission reductions were provided by Transnet.

Nitrous Oxide Reduction Projects

No calculations were conducted as the emission reductions were available from the data provided by the Chemical Allied Industries Association (CAIA).

Conservation Agriculture

The AFOLU strategy (DEFF, 2020) reports that in 2018, conservation areas constituted 14% of the annual crop area, which was 11,126,022 hectares (DEA, 2019). These conservation areas have been expanding at an annual growth rate of 7.5%. The mitigation potential factor is estimated at 0.2 tC/ha/yr, although DEFF 2020 initially applied a higher value of 0.3 tC/ha/yr. However, due to the partial adoption of conservation activities (Findlater et al., 2019), the lower value of 0.2 tC/ha/yr was used. It is assumed that soil carbon will accumulate over the IPCC default period of 20 years, with the annual growth rate in conservation areas remaining constant at 7.5% per year.

Grassland Restorations

No calculations were undertaken since the data was extracted from the NIR 2022, for GHG emission reductions from cropland converted to grassland, settlements converted to grassland and other land converted to grassland.

Afforestation

No calculations were undertaken since the data was extracted from the NIR 2022, for GHG emission reductions from conversions of cropland/grassland/wetland/settlements/other land to indigenous forest/plantation/woodland.

Forest and Woodland Restoration and Rehabilitation

No calculations were undertaken since the data was extracted from the NIR 2022, for the GHG emission reductions from land use conversions that include forestland converted to indigenous forest and woodlands.

Municipal Landfill Gas Destruction

No calculations were undertaken as part of this report. High-level, secondary data sets were provided (in MtCO2e) by the Department of Environment, Forestry and Fisheries for the years 2011-2017 and in 2021. For reporting emission reductions in years 2018 to 2020; it was assumed that the same amount of landfill gas was captured and saving the equivalent amount of MtCO2e as in the last recorded year of 2017. For reporting emission reductions in 2022; it was assumed that the same amount of landfill gas was captured and saving the equivalent amount of $MtCO_2e$ as in the last recorded year of 2021.

National Waste Management Strategy

No calculations were undertaken as part of this report. High-level, secondary data sets were provided (in $MtCO_2e$) by the Department of Environment, Forestry and Fisheries for the years 2010-2020. For reporting emission reductions in years 2021 and 2022; it was assumed that the waste diversion projects were ongoing and saving the equivalent amount of $MtCO_2e$ as in the last recorded year of 2020.