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Climate Change Assessment for the Proposed Harmony West Wits Reclamation and Deposition Project

Project done on behalf of **Environmental Impact Management Services**

Project Compiled by:

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Revision Record

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Rev 0	31 August 2026	For internal review
Rev 1	15 October 2026	Addressed client comments

EXECUTIVE SUMMARY

Airshed Planning Professionals (Pty) Ltd was appointed by EIMS to undertake a Climate Change Assessment (CCA) for the proposed new Deelkraal II Tailings Storage Facility (TSF) project and associated infrastructure (i.e. the Proposed Harmony West Wits Reclamation and Deposition Project) on a site located approximately 13 km southwest of Carletonville in the Merafong City Local Municipality, West Rand District Municipality, Gauteng Province.

A Climate Change Assessment (CCA) was conducted to determine the potential long term climate change impacts as a result of the Current-, Construction- and Project operations. Greenhouse gas (GHG) emissions for the project were calculated based on the Department of Forestry, Fisheries and Environment (DFFE) 2022 Methodological guidelines for quantification of GHG emissions which are based on the Intergovernmental Panel on Climate Change (IPCC) emission factors. This study considered Scope1, Scope 2 and Scope 3 emissions, where Scope 1 are the emissions directly attributable to the project and Scope 2 emissions are the emissions associated with bought-in electricity. Scope 3 emissions consider the "embedded" carbon in bought-in materials and transport as well as the use of exported materials.

The findings of the assessment are summarised below:

- The region around Carletonville, where the project will be developed, is likely to experience increased temperatures and extreme weather-related events in the future. Climate change impacts will disproportionately affect underdeveloped communities that lack the physical and financial resources to cope with the physical effects of climate change, such as droughts, floods and increases in diseases.
- Scope- 1, 2 and 3 emissions were estimated based on emission factors and expected construction activities, and production rates or raw material use. The main construction activities attributed to GHG emissions are the development of the new Deelkraal II TSF and the refurbishment of the Kusasalethu Gold plant.
- The Kusasalethu processing plant is currently under care and maintenance and activities are limited to asset preservation, preventative maintenance and operation of essential services. Quantified greenhouse gas (GHG) emissions from the current operations are mainly Scope 2 emissions (94.6%) with little contribution from Scope 1 (0.7%) and Scope 3 (4.8%).
- Construction operations would only result in Scope 3 emissions with all Scope 1 and Scope 2 falling under current operations. Scope 3 emissions from the Construction of the proposed Deelkraal II TSF would result in 23 879 t CO_2e per annum while 21 149 t CO_2e per annum will result from the refurbishment of the Kusasalethu Gold plant.
- During future operations, the electricity bought from ESKOM (Scope 2) is the main source (89.3%), followed by Scope 3 emissions (5.4%) and Scope 1 emissions (5.3%). The main source of Scope 3 GHG emissions would be upstream transportation (63% of Scope 3 emissions), followed by Capital goods/ assets (incoming) at 15% and Employee commuting (13%).
- Construction of the proposed project in combination with the current operational-related GHG emissions will have a **Very Low** negative risk.
- Based on information provided, the project is likely to result in an estimated total of 9 557 t CO_2e per annum direct emissions (Scope 1) and 162 349 t CO_2e per annum indirect emissions (Scope 2) due to operational

activities, with 9 749 t CO_2e per annum indirect (Scope 3) emissions. The GHG emissions from the project for the operation was calculated to represent 0.054% of the remaining South African annual budget for 2035. The impact of the project on climate change was assessed to have a **Medium** negative risk rating.

The project will be required to report CO_2e emissions annually via the National Atmospheric Emission Inventory System (NAEIS).

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LIST OF ACRONYMS AND SYMBOLS

AFF	Agriculture, Forestry and Fishing
AR5	IPCC's fifth assessment report
AR6	IPCC's sixth assessment report
BAU	Business-As-Usual
°C	Degrees Celsius
CCA	Climate Change Assessment
CCRA	Climate Change Reference Atlas
CCS	Carbon Capture and Sequestration (or Carbon Capture and Storage)
CH_4	Methane
CMIP	Coupled Model Intercomparison Project
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
DEFRA	UK Department for Environment Food & Rural Affairs
DFFE	Department of Forestry, Fisheries and Environment (previously DEA)
DWS	Department of Water and Sanitation
EAPs	Environmental Assessment Practitioners
EBRD	European Bank for Reconstruction and Development
ECMWF	European Centre for Medium-Range Weather Forecasts
EIA	Environmental Impact Assessment
ERA5	Fifth generation ECMWF (European Centre for Medium-Range Weather Forecasts)
GCMs	Global Climate Change Models
GDP	Gross domestic product
GG	Government gazette
GHG	Greenhouse gases
GHGIP	National Greenhouse Gas Improvement Programme
GN	Government notice
GVA	Gross Value Added
GWP	Global warming potential
ha	Hectare
H_2O	Water vapour
HFCs	Hydrofluorocarbons
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
kg	Kilogram
km	Kilometre
kWh	Kilowatt hour
LUCF	Land-Use Change and Forestry LUCF
LULUCF	Land Use, Land Use Change and Forestry
mm	Millimetres
mm/yr	Millimetres per year
MW	Megawatt
N_2O	Nitrous oxide
NAAQS	National Ambient Air Quality Standards
NAEIS	National Atmospheric Emission Inventory System
NCEP	National Centres for Environmental Prediction
NEM:AQA	National Environmental Management: Air Quality Act

NDCs	Nationally determined contributions
NOAA	National Oceanic and Atmospheric Administration
O_3	Ozone
PFCs	Perfluorocarbons
ppm	Parts per million
PPP	Pollution Prevention Plan
PUFA	Polyunsaturated fatty acids
PV	Photovoltaic
RCA4	Rossby Centre regional model
RCPs	Representative Concentration Pathways
REDD+	Reducing Emissions from Deforestation and forest Degradation
SA	South Africa
SAAELIP	South African Atmospheric Emission Licensing and Inventory Portal
SAAQIS	South African Air Quality Information System
SACNASP	South African Council for Natural Scientific Professions
SAGERS	South African Greenhouse Gas Emission Reporting System
SAWS	South African Weather Services
SF_6	Sulfur hexafluoride
SPI	Standardized Precipitation Index
SSP	Shared Socioeconomic Pathway
SST	Sea surface temperatures
t	Tonne
TJ	Terajoule
ton/ha	Tonne per hectare
TCFD	Taskforce for Climate-related Financial Disclosures
UNFCCC	United Nations Framework Convention on Climate Change

Note:

The spelling of “sulfur” has been standardised to the American spelling throughout the report. "The International Union of Pure and Applied Chemistry, the international professional organisation of chemists that operates under the umbrella of UNESCO, published, in 1990, a list of standard names for all chemical elements. It was decided that element 16 should be spelled “sulfur”. This compromise was to ensure that in future searchable data bases would not be complicated by spelling variants. (IUPAC. Compendium of Chemical Terminology, 2nd ed. (the "Gold Book"). Compiled by A. D. McNaught and A. Wilkinson. Blackwell Scientific Publications, Oxford (1997). XML on-line corrected version: http://goldbook.iupac.org (2006) created by M. Nic, J. Jirat, B. Kosata; updates compiled by A. Jenkins. ISBN 0-9678550-9-8.doi: 10.1351/goldbook)"

1 INTRODUCTION

Randfontein Estates Limited (a subsidiary of Harmony Gold Mining Company) (hereafter referred to as the applicant) has appointed Environmental Impact Management Services (Pty) Ltd (EIMS) as the Environmental Assessment Practitioner (EAP) to assist with undertaking the required authorisation processes and to compile and submit the required documentation in support of application for the proposed new Deelkraal II Tailings Storage Facility (TSF) project and associated infrastructure (i.e. the Proposed Harmony West Wits Reclamation and Deposition Project) on a site located approximately 13 km southwest of Carletonville in the Merafong City Local Municipality, West Rand District Municipality, Gauteng Province.

Airshed Planning Professionals (Pty) Ltd was appointed by EIMS to undertake a Climate Change Assessment (CCA) for the proposed new Deelkraal II TSF project (hereafter referred to as the Project).

1.1 Project Description

The Applicant requires additional deposition capacity for West Wits region's operations. The applicant plans on constructing the Deelkraal II TSF to cater for the additional future capacity. This TSF will receive residue from Kusasalethu, and Savuka plants and will also assist in returning process water for reclaiming the existing Deelkraal I TSF and Kusasalethu TSF for processing at Kusasalethu plant. Additional planned infrastructure includes slurry, potable, sewage and return water pipelines, access roads, pump stations, a return water dam and a power line. Proposed upgrades to the existing Kusasalethu plant are also proposed as part of the project.

The Savuka Plant treats tailings from the Savuka Dormant TSFs (Old North TSFs) at a rate of 330 000 tpm and deposits the subsequent tailings on Savuka 5 & 7 TSFs. Harmony plans on remining Deelkraal 1 Dormant TSF and Kusasalethu TSF amongst other potential future sources. These TSFs will be processed through the Kusasalethu Plant at 500 000 tpm. The planned Life of Mine (LOM) for the West Wits region exceed the available deposition capacity of the existing TSFs. Therefore, additional deposition capacity is required.

The Kusasalethu Plant will accommodate future reclamation operations and will, therefore, need site/s to deposit the tailings. Harmony owns ground, located adjacent to the Deelkraal 1 Dormant TSF, that can be used for the proposed Deelkraal II TSF. The Deelkraal 1 Dormant TSF and adjacent virgin ground footprint combined geometry will accommodate the future reclamation operations deposition rate and capacity. The proposed TSF will cover an area of approximately 430 ha.

In addition to the Deelkraal II TSF, additional infrastructure is also proposed, as follows:

- A new Return Water Dam in the vicinity of the Deelkraal II TSF;
- Upgrades to the existing Kusasalethu plant including new/upgrade of gold and new uranium sections;
- Slurry pipelines:
    - Reclaimed Slurry from Deelkraal 1 to Kusasalethu (~10.6 km);
    - Kusasalethu Barren Tailings to Deelkraal II and booster pump station (~10.2 km);
    - Reclaimed Slurry from Kusasalethu TSF to Kusasalethu Plant (~2 km);
    - Slurry pipeline from Kusasalethu Plant to Savuka TSF (~4.97 km); and,
    - Slurry pipeline from Savuka plant to DF5 TSF (~2.9 km).

- Process Water Pipelines:
    - Process Water Feed from Kusasalethu Plant to Deelkraal Reclamation (~9.54 km) –
    - Return Water Feed to Kusasalethu Process Water Tank (~9.58 km); -
    - Driefontein DP2 Pump Station to North Boundary Dam (~4.78 km); -
    - DP2 feed to Tau Tona Reverse Osmosis Plant (~0.1 km); -
    - Nursery Pumpstation #3 to Kusasalethu Process Water Tank (~9 km); and
    - Process Water pipelines from Kusasalethu Plant to Savuka White Tanks (~8 km).
- Powerlines (all powerlines will be 22 kV or lower):
    - Powerline from Kusasalethu Plant to the existing Deelkraal TSF (~9.2 km);
    - Powerline from Kusasalethu Plant to the Kusasalethu TSF (~1.8 km);
    - Powerline from Savuka shaft to Kusasalethu Plant (~8.1 km).
- Potable Water pipeline from Rand Water supply point to the Deelkraal TSF (~8.52 km).
- Deelkraal 1 TSF Reclamation Pump Station.
- Kusasalethu TSF Reclamation Pump Station.
- New Access Roads (2 x 3.5 m double road) adjacent to pipeline routes/overhead lines and around Deelkraal II TSF (where no access road is already in place).
- Topsoil Stockpiles and overburden stockpiles.
- Ancillary construction infrastructure including workshops and laydown areas.

The layout of the proposed new TSF and associated infrastructure are provided in Figure 1-1.

1.2 Scope of Work

The scope of work included a desktop CCA in line with the Consultation on Intention to Publish the National Guideline for Consideration of Climate Change Implications in Applications for Environmental Authorisations, Atmospheric Emission Licenses, and Waste Management Licenses, by:

1. Quantifying the greenhouse gas (GHG) emissions during the construction, operation, and closure and decommissioning phases of the project compared to the global and national emission inventories; and compared to international benchmarks for the project.
2. Discussing the robustness of the project in terms of forecasted climate change impacts to the area over the lifetime of the project.
3. Discussing the vulnerability of communities in the immediate vicinity of the project to climate change.
4. Proposing management and mitigation strategies.
5. Preparation of a climate change statement report.

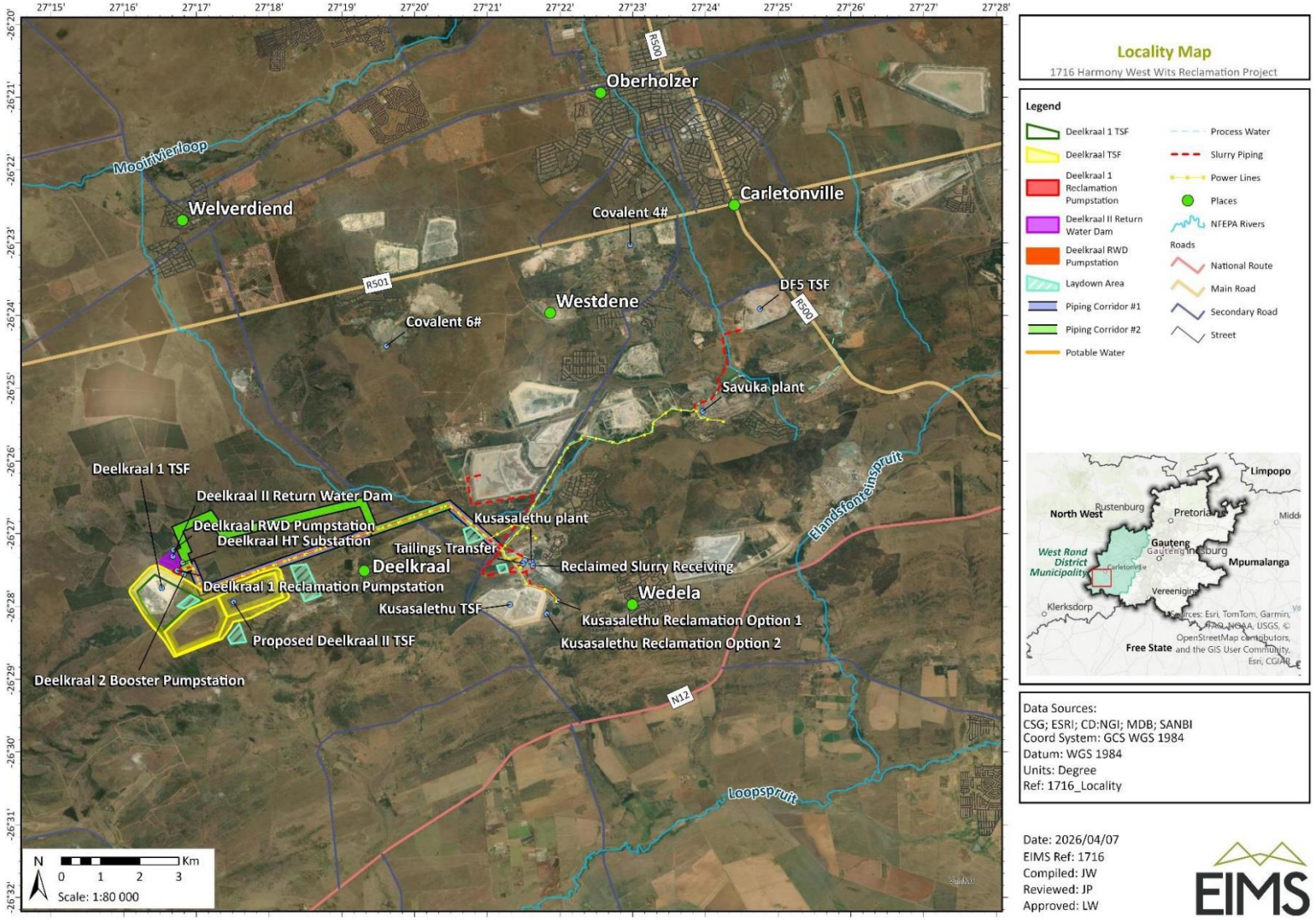


Figure 1-1: Location of the project (provided by EIMS)

1.3 Specialist Details

1.3.1 Statement of Independence

Airshed is an independent consulting firm with no interest in the project other than to fulfil the contract between the client and the consultant for delivery of specialised services as stipulated in the terms of reference.

1.3.2 Competency Profile – H Liebenberg-Enslin, PhD Geography (University of Johannesburg)

After earning her master's degree in science from the University of Johannesburg (formerly RAU) in Geography and Environmental Management. Hanlie Liebenberg-Enslin began her professional career in air quality management in 2000 when she joined Environmental Management Services (EMS). She received her PhD from the University of Johannesburg in June 2014 specialising in aeolian dust transport. She is one of the founding members of Airshed Planning Professionals and served as a director of the organization until May 2013, when she assumed the role of managing director.

She has worked across Africa and has considerable experience in the many aspects of air quality management, including impact- and health risk screening assessments, dispersion modelling simulations, and emissions quantification for a variety of source types. Hanlie has been involved in a few United Nations Environmental Programme (UNEP) projects and served as the project manager on numerous innovative air quality management plan (AQMP) developments. She also participates actively in the National Association for Clean Air (NACA) and the International Union of Air Pollution Prevention and Environmental Protection Associations (IUAPPA). She served as an external examiner for various MSc and PhD dissertations and lectured at air quality management courses.

A comprehensive curriculum vitae of Hanlie Liebenberg-Enslin is provided in Appendix A. The declaration of independence for Hanlie Liebenberg-Enslin is provided in Appendix B.

2 REGULATORY CONTEXT AND IMPACT ASSESSMENT CRITERIA

GHGs are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property is known as the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine and bromine containing substances, dealt with under the Montreal Protocol. Beside CO_2, N_2O and CH_4, the Kyoto Protocol deals with the greenhouse gases sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) (IPCC, 2007). Human activities since the beginning of the Industrial Revolution (taken as the year 1750) have produced a 40% increase in the atmospheric concentration of carbon dioxide, from 280 ppm in 1750 to 415 ppm in early September 2021 (NOAA, 2021). This increase of CO_2 in the Earth's atmosphere has occurred despite the uptake of a large portion of the emissions by various natural "sinks" involved in the carbon cycle (NOAA, 2021). Anthropogenic CO_2 emissions (i.e., emissions produced by human activities) come from combustion of fossil fuels, principally coal, oil, and natural gas, along with waste processing and decomposition, deforestation, soil erosion and animal agriculture (IPCC, 2007).

The following sections describe the alignment of South African national policies regarding GHG emissions and reporting with international agreements and targets.

2.1 International Agreements

In 1992, countries joined an international treaty, the United Nations Framework Convention on Climate Change, (UNFCCC) as a framework for international cooperation to combat climate change by limiting average global temperature increases and the resulting climate change, and coping with impacts that were, by then, inevitable.

By 1995, countries launched negotiations to strengthen the global response to climate change, and, two years later, adopted the Kyoto Protocol. The Kyoto Protocol legally binds developed country parties to emission reduction targets. The Protocol's first commitment period started in 2008 and ended in 2012. As agreed in Doha in 2012, the second commitment period began on 1 January 2013 and will end in 2020 (UNFCCC, 2017) but due to lack of ratification has not come into force.

The Paris Agreement (2016) builds upon the Convention and – for the first time – brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. As such, it charts a new course in the global climate effort.

The central aim of the Paris Agreement is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2.0°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C. Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. To reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their own national objectives.

The Paris Agreement requires all Parties to put forward their best efforts through "nationally determined contributions" (NDCs) and to strengthen these efforts in the years ahead. This includes requirements that all Parties report regularly on their emissions and on their implementation efforts.

In 2018, Parties took stock of the collective efforts in relation to progress towards the goals set in the Paris Agreement to inform the preparation of NDCs. There will also be a global stocktake every five years to assess the collective progress towards achieving the purpose of the Agreement and to inform further individual actions by Parties.

As of September 2024, 195 Parties of the 198 Parties to the UNFCCC Convention, including South Africa, had ratified the Paris Agreement. South Africa submitted its NDC to the UNFCCC on 25 September 2016 and an updated first NDC in September 2021. In October 2025, the second NDC was submitted.

On January 20, 2025, an executive order was signed by the President to withdraw the United States of America from the Paris Agreement.

2.2 South African National Climate Change Response Policy

South Africa ratified the UNFCCC in August 1997 and acceded to the Kyoto protocol in 2002, with effect from 2005. However, since South Africa is a Non-annex 1 country it implies no binding commitment to cap or reduce GHG emissions. South Africa later also ratified the Paris Agreement (as signed on 22 April 2016) which although not bound to commit to a cap or reduce GHG emissions, pledged to reduce emissions by 34% below Business-As-Usual (BAU) emissions by 2020 and 42% below BAU by 2025. The proposed 2030 target range represents a 28% reduction in GHG emissions commitment from the original 2015 NDC targets. However, these original goals were ambitious, and South Africa subsequently shifted from BAU-based targets for 2020 and 2025 in terms of the Cancun Agreement under the UNFCCC, to absolute GHG emissions targets under the Paris Agreement. This update demonstrates reducing the upper range of South Africa's targets by a more realistic 28% for 2030.

The National Climate Change Response White Paper, passed by Cabinet in October 2011, stated that in responding to climate change, South Africa has two objectives: to manage the inevitable climate change impacts and to contribute to the global effort in stabilising GHG emissions at a level that avoids dangerous anthropogenic interference with the climate system. The White Paper proposes mitigation actions, especially a departure from coal-intensive electricity generation, be implemented in the short- and medium-term to match the GHG trajectory range. Peak GHG emissions are expected between 2020 and 2025 before a decade long plateau period and subsequent reductions in GHG emissions.

The White Paper also highlighted the co-benefit of reducing GHG emissions by improving air quality and reducing respiratory diseases by reducing ambient particulate matter, ozone, and sulfur dioxide concentrations to levels in compliance with the National Ambient Air Quality Standards (NAAQS) by 2020. To achieve these objectives, the Department of Forestry, Fisheries and the Environment (DFFE) established a national GHG emissions inventory that reports through the South African Atmospheric Quality Information System (SAAQIS).

The Climate Change Act (Act 22 of 2024) was assented to by the President of the Republic of South Africa on 23 July 2024 in Government Notice (GN) 5050 in Government Gazette (GG) 50966 of 23 July 2024. The President proclaimed its commencement under section 38 on 17 March 2025; however not all provisions are in force. The

Act is aligned with international policies guidelines and South Africa's NDC and aim to reduce GHG emissions as primary driver to anthropogenic climate change. The aim of the Act is to achieve an effective climate change response through a long-term just transition to a low carbon economy that is climate resilient and allows for sustainable development of South Africa. When in force, the Act will:

- establish provincial and municipal forums on climate change which will be responsible for co-ordinating climate change response actions in each province.
- strengthen the establishment of the Presidential Climate Change Coordinating Commission.
- establish a National Adaptation Strategy to guide South Africa's adaptation to the impacts of climate change and develop adaptation scenarios which anticipate the likely impacts over the short, medium, and long term.
- determine a national GHG emissions trajectory, which must be reviewed every five years, and which indicates an emissions reduction objective.
- put in place a 5-yearly sectoral emission targets for identified sectors and sub-sectors that must be aligned with the national GHG emissions trajectory and include quantitative and qualitative GHG emission reduction goals.
- bring into force the carbon budget allocation mechanism, which will be linked to the Carbon Tax Act, which will replace the current National Pollution Prevention Plan mechanism which is enforced under the National Environmental Management: Air Quality Act (NEM:AQA).

2.3 Nationally Determined Contribution

The first South African Nationally Determined Contribution (NDC) submission was completed in 2016. This was undertaken to comply with decision 1/CP.19 and 1/CP.20 of the Conference of the Parties to the UNFCC. An update of the first NDC was published submitted to the UNFCCC on 27 September 2021[1] in preparation for the 26th Conference of the Parties (held in Glasgow, Scotland in November 2021). South Africa's Second Nationally Determined Contribution under the Paris Agreement was published in October 2025. Since 2021, South Africa has shifted from primarily developing climate strategies to implementing a legally binding climate framework, accelerating the energy transition, operationalising adaptation measures, and embedding a just transition approach across climate and industrial policy.

This document describes South Africa's NDC on adaptation, mitigation and finance and investment necessities to undertake the resolutions with updated revisions to the adaptation goals and mitigation targets.

South Africa has made significant advances in strengthening its climate policy, governance, mitigation, and adaptation efforts:

[1] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/South%20Africa%20First/South%20Africa%20updated%20first%20NDC%20September%202021.pdf

1. Stronger legal and policy framework

- The Climate Change Act (2024) was passed, providing South Africa with its first comprehensive legal framework for climate action.
- The Act allocates responsibilities for climate adaptation and mitigation across government sectors and establishes guiding principles for implementation.
- The Act also requires the National Greenhouse Gas Emissions Reduction Trajectory (NGERT) to be reviewed every five years, informing future NDCs.

2. Enhanced mitigation and decarbonisation ambitions

- South Africa has moved beyond the original "Peak, Plateau and Decline" emissions approach towards a commitment to achieve net-zero CO_2 emissions by 2050 through a just transition.
- The Carbon Tax Act (2019) has been implemented and is progressing into a second phase with a higher tax rate.
- The Integrated Resource Plan (IRP) for electricity was updated in 2025, supporting the transition to a lower-carbon energy system.

3. Clear long-term transition pathway

- 2020s: Focus on decarbonising the electricity sector.
- 2030s: Deepen power sector transformation and accelerate the shift to low-emission transport.
- 2040s and beyond: Address hard-to-abate sectors through deeper industrial decarbonisation.

4. Progress on climate adaptation

- South Africa's National Climate Change Adaptation Strategy (NCCAS), adopted in 2020 and submitted to the UNFCCC in 2021 as the country's National Adaptation Plan (NAP), has shifted the focus from planning to implementation.
- Greater support is being provided to provincial and local governments to implement adaptation measures under the Climate Change Act.

5. Strengthened climate governance and institutions

- The Presidential Climate Commission (PCC), established in 2018, has developed a national Just Transition Framework and had its role formalised through the 2024 Climate Change Act.
- Government continues to improve institutional coordination and capacity to deliver integrated climate policies.

6. Just Energy Transition and international partnerships

- South Africa launched the world's first Just Energy Transition Partnership (JETP) with international partners.
- JETP investment and implementation plans support ambitious emissions reductions while promoting social inclusion and ensuring vulnerable communities are not left behind.

7. Green industrial development and regional cooperation

- Industrial policy increasingly promotes green industrialisation, economic diversification, and decarbonisation.
- South Africa is working with other African countries to strengthen regional value chains for critical minerals, expand beneficiation opportunities, and promote continental trade in support of a low-carbon economy.

Mitigation targets reflect the country's highest possible ambition and are put forward in the context of equity, common but differentiated responsibilities, and respective capabilities, in the light of different national circumstances. The 2024 Climate Change Act mandates a National GHG Emission Reduction Trajectory (NGERT), which will be updated every five years. Until a new NGERT has been determined, in terms of the Act, this second NDC serves as the trajectory. South Africa is at the same updating our Long-term Low Emissions Development Strategy consistent with our Just Transition Framework, which specifies the goal of reaching net zero CO_2 emissions by 2050.

The updated second NDC mitigation targets are presented in Table 2-1.

Table 2-1: South Africa's draft second NDC mitigation targets

Period of implementation	Target
2031 – 2035	South Africa's annual GHG emissions will be in a range from 320 – 380 Mt CO_2e in 2035.

South Africa identified five goals in our updated and enhanced NDC in 2021 where the second NDC of 2025 identified eight goals, together with priority interventions to achieve them, ways of tracking progress, and support needed. These are provided in Table 2-2.

Table 2-2: National adaptation goals, interventions, ways of tracking and finance needs in South Africa's Adaptation Communication in its second NDC

National goals for the period 2031-2035	Priority interventions to achieve goal	Ways to track progress of adaptation	Adaptation finance needed (2026-35, ZAR millions, nominal)
Goal 1: Adapt South Africa's water and sanitation systems to drying conditions and drought and flood intensification, as water underpins human, plant and animal health and all economic and livelihood activities.	Support municipalities develop updated water preparedness plans and water safety plans; Programmes to reduce water losses and non-revenue water; Enhanced water monitoring (flows, quality, consumption); Restore catchments and wetlands, removing invasive alien plants; Revise water allocations, restrictions and pricing; Water augmentation and diversification schemes, focusing on reuse and groundwater; Innovate with low-flow and waterless sanitation solutions; Expand water stewardship programmes; Invest in regional, transboundary water management arrangements	Share of updated reconciliation and planning studies for bulk water supply system and all towns studies; Number of municipalities reporting water losses over a quarter of supply; Share of service providers achieving blue and green drop status; Share of wastewater reuse; Total area with maintained removal of invasive alien plants; Total area formally under water stewardship programmes.	197,000
Goal 2: Enhance disaster risk management, healthcare and sanitation provision, especially in informal settlements, to reduce impacts of flooding and heat stress on most vulnerable households.	Emergency support on accommodation for flood-displaced marginalized groups in high-risk municipalities; Training and support to community-based organizations providing care services to young children, elderly and people living with disabilities; Enhance clinical resources to diagnose and treat water- and vector-borne diseases; Extend and upgrade sanitation services in high-risk informal settlements, especially near food vendors	Perceived access to safe spaces captured in census; Loss of lives in flood and heatwave events; Ratio of households to toilet facilities; Incidence of cholera and diarrheal disease.	1,865

National goals for the period 2031-2035	Priority interventions to achieve goal	Ways to track progress of adaptation	Adaptation finance needed (2026-35, ZAR millions, nominal)
Goal 3: Upgrade critical transport infrastructure (roads, rail, ports) to maintain functioning under increased rainfall intensity, heat stress, wind speeds and storm surges.	Expand maintenance programmes to remove blockages (e.g. invasive plants, solid waste, wind-blown sand); Coastal dune rehabilitation; Flood and erosion defences; Upgrade built and ecological drainage infrastructure; Upgrades to transmission and distribution infrastructure; Managed retreat and relocation of key infrastructure from high-risk zones.	Reported road closures and repair costs; Logistics and supply chain interruptions and port backlogs; Disaster incident reports.	30,750
Goal 4: Enhance nutritious food access and affordability through support to agricultural and fisheries producers and distributors in adapting to warmer and windier conditions and changes in rainfall.	Support to develop, adopt & market drought-resistant crop varieties and heat-tolerant livestock and aquaculture species; Enhance market access for small-scale producers; Improve irrigation efficiency; Training and accreditation of sustainable land management and sustainable fishing and aquaculture practices; Enhance access to tailored climate information; Affordable climate risk insurance schemes; Support with shade-netting infrastructure.	Increase in annual average cost of basic food basket; Number of extension officers per district; Share of children under 5 presenting signs of malnutrition; Incidence of vector-borne diseases in livestock; Registered crop losses.	1,246
Goal 5: Enhance climate services, with early warning and impact information made accessible to a wide range of users, tailored to different operational, language, gender, age and disability needs.	Enhance early warning systems (monitoring, warning dissemination and response triggers), building on SAWS multi-hazard EWS; Train community leaders in climate information interpretation and response measures, and how to ensure that implementation of all interventions is socially inclusive and gender responsive; Develop a national inventory of impacts to complement EWS with bottom-up data collection, the DFFE coordinating and supporting efforts by local authorities and communities; SADC integrated regional drought-monitoring system.	Number of hydro-met monitoring stations operational; Number of registered users and active data contributors to climate services platform.	6,036

National goals for the period 2031-2035	Priority interventions to achieve goal	Ways to track progress of adaptation	Adaptation finance needed (2026-35, ZAR millions, nominal)
Goal 6: Enhance ecosystem-based adaptation to heat and water stress, protecting South Africa's natural heritage, biodiversity and improving ecosystem functioning that underpins our cultural identity, food systems, human wellbeing and our tourism economy.	Redesign national-scale agricultural extension programme to support sustainable rangeland management and fire management; Spatially targeted restoration initiatives in critical biodiversity areas and ecological support areas, especially strategic water source areas; Invasive alien plant clearing and management; Review ecological reserve determinations for surface and groundwater catchments; Expand conservation estate and protected area network; Strengthen protected area management; Expand land and water stewardship programmes.	Coverage of protected area network, extent and share of total land area; Distribution of indicator species.	9,090
Goal 7: Capacitate all spheres of government to implement adaptation through enacting and enforcing all provisions of Climate Change Act.	Develop and implement sector adaptation strategies and plans, consistent with NCCAS; Network of project preparation facilities supporting municipalities access suitable financing for robust adaptation interventions; Climate jobs register with a focus on youth and gender inclusion; Fully functioning adaptation MEL system for routine BRT and GST reporting.	Annual adaptation spend; Number of climate jobs filled; Sector adaptation strategies and Plans reviewed and adjusted every five years; Adaptation synthesis reports published.	4,229
Goal 8: Enhanced efforts to build climate-resilient human settlements and resilient infrastructure.	Develop the Human Settlement Climate Change Adaptation Strategy / Climate Change Response Strategy and/or Plan; Conduct climate risk and vulnerabilities on Priority Human Settlement and Housing Development Areas; Support ecological infrastructure interventions as part of building the climate-resilient infrastructure.	Number of instruments and tools developed and implemented to integrate climate consideration in spatial planning and human settlements.	

2.4 Greenhouse Gas Emissions Reporting

Regulations pertaining to GHG reporting using the National Atmospheric Emission Inventory System (NAEIS) were published on 3 April 2017 (GN 257 in GG 40762 and amendment – GNR 994 in Government Gazette 43712). The South African mandatory reporting guidelines focus on the reporting of Scope 1 emissions only. The three broad scopes for estimating GHG are:

- Scope 1: All direct GHG emissions.
- Scope 2: Indirect GHG emissions from consumption of purchased electricity, heat or steam.
- Scope 3: Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities not covered in Scope 2, outsourced activities, waste disposal, etc.

The South African Greenhouse Gas Emission Reporting System (SAGERS) web-based monitoring and reporting system is used to collect GHG information in a standard format for comparison and analyses. The system forms part of the national atmospheric emission inventory component of South African Atmospheric Emission Licensing and Inventory Portal (SAAELIP).

The DFFE published its draft methodological guideline document on 19 February 2021 (Government Gazette No. 44190) with the updated methodological guidelines on 7 October 2022 (Methodological Guidelines for Quantification of Greenhouse Gas Emissions - Government Gazette No. 47257) (DFFE, 2022), which describes the reporting methodology as specified in the NEM:AQA (Act No. 39 of 2004): National Greenhouse Gas Emission Reporting Regulations (NGERs).

Also, the Carbon Tax Act (No 15 of 2019) (Republic of South Africa, 2019) includes details on the imposition of a tax on the CO_2-e of GHG emissions. Certain production processes indicated in Annexure A of the Declaration of Greenhouse Gases as Priority Pollutants (Republic of South Africa, 2017) with GHG more than 0.1 mega tonnes (Mt) or million metric tonnes, measured as CO_2-e, are required to submit a pollution prevention plan to the Minister for approval.

2.5 GHG Inventories

2.5.1 National GHG Emissions Inventory

South Africa is a GHG contributor and is undertaking steps to mitigate and adapt to the changing climate. DFFE is categorised as the lead climate change institution and is required to coordinate and manage climate related information such as development of mitigation, monitoring, adaption and evaluation strategies (DFFE, 2022a). This includes the establishment and updating of the National GHG Inventory.

The 2020 National GHG Inventory (DFFE, 2022a), which includes inventories from 2000 to 2020, was prepared using the 2006 IPCC Guidelines (IPCC 2006) and IPCC Good Practice Guidance (GPG) (IPCC ,2000; IPCC, 2003; IPCC, 2014). This report has been superseded by the 2022 National GHG Inventory (DFFE, 2024), The national GHG inventory covers five sectors, namely (DFFE, 2024):

- Energy, including:
    - Exploration and exploitation of primary energy sources;
    - Conversion of primary energy sources 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.
- Industrial Process and Product Use (IPPU).
- Agriculture
- Land Use, Land Use Change and Forestry (LULUCF)
- Waste.

Agriculture, Forestry and Other Land Use (AFOLU) were reported in the 2020 National GHG Inventory the as a single sector. This sector has been replaced by two sectors, namely Agriculture and LULUCF in the 2022 National GHG Inventory. The latest report covers sources of GHG emissions, and removals by sinks, resulting from human or anthropogenic activities for the major GHGs, including:

- CO_2,
- CH_4,
- N_2O,
- perfluorocarbons (PFCs), and
- hydrofluorocarbons (HFCs).

Indirect greenhouse gases – CO and NOx – are also included for biomass burning. Sulphur hexafluoride (SF_6) emissions have not yet been included due to a lack of data.

To standardise the impact of these different gases on climate change, the IPCC introduced the Global Warming Potential (GWP), which is a metric developed to measure how much heat a specific GHG traps in the atmosphere over a specific time period - usually 20, 100, or 500 years - relative to carbon dioxide (CO_2). Each of the major GHGs are therefore presented as CO_2 equivalents (CO_2-e) using the 100-year period.

The IPCC Guidelines recommend that when calculating non-CO_2 GHG emissions, the most recent GWPs are used. However, under NGERs, which stipulates national reporting requirements, data providers are required to use GWP values provided by the IPCC 3rd Assessment Report (IPCC 2001), where required (SA Technical Guidelines for Monitoring, Reporting and Verification of GHG Emissions (MG-2022,1 October 2022 Annexure H (DFFE, 2022)):

- CH_4 emissions should have a multiplier of 23; and
- N_2O emissions should have a multiplier of 296.

The GHG Protocol, however, states that the IPCC 2nd, 3rd or 4th Assessment Report GWPs can be used, as long as they are referenced correctly and used consistently. Table 2-3 below is a summary of GWP values published by the IPCC, the NGERs requirement and those used in the two national GHG inventories.

Table 2-3:Progressive development of GWP values with IPCC Assessment Reports, application in the National GHG Inventories and that stated in the NGERs

Application	100-Year GWP		
	CO_2	CH_4	N_2O
2nd Assessment (AR2)	1	21	310
3rd Assessment (AR3)	1	23	296
4th Assessment (AR4)	1	25	298
5th Assessment (AR5)	1	28	265
6th Assessment (AR6)	1	29.8 (fossil) 27.2 (non-fossil)	273
DFFE 2020 GHG Report	1	21	310
DFFE 2022 GHG Report	1	28	265
NGERs	1	23	296

In the latest IPCC assessment, (IPCC 6th Assessment Report), the GWP for CH_4 has been estimated separately for fossil (29.8) and non-fossil fuels (27.2) with an uncertainty of ±11, which is different from the previous GPWs. The GWP for N_2O has been estimated as 273 with an uncertainty of ±130. The IPCC also provides GWP for other periods, including 20 years and 500 years. With the above GWP for CH4 (fossil fuel), its presence therefore has an estimated warming potential of 29.8±11 over 100 years, but 82.5±25.8 over 20 years; conversely N_2O has a GWP of 273±130 over both 20 and 100 years.

It should be noted that when reporting on the DFFE SAGERS Portal, data providers are required to report direct emissions and not CO_2-e. The system will generate a report based on the relevant GWPs when the data provider downloads the annual report.

A substance's GWP is based on the energy absorbed over a period and therefore depends on the number of years over which the potential is calculated. The GWP value therefore depends on how the gas concentration decays over time in the atmosphere. GWPs based on a shorter timeframe will be larger for gases with lifetimes shorter than that of CO_2, and smaller for gases with lifetimes longer than CO_2. For example, for CH_4, which has a short lifetime, the AR5 100-year GWP of 28 is much less than the 20-year GWP of 84. N_2O, on the other hand, has a long lifetime, and the AR5 100-year GWP of 265 is nearly the same as the 20-year GWP of 264. The 100- year GWP is the most used and is also adopted in the National GHG reporting guidelines.

The 2022 National GHG Inventory uses the GWPs from the 2014 IPCC 5th Assessment Report (AR5) (IPCC, 2014b) whereas the previous inventory (2020 National GHG Inventory) the 100–year GWPs from the 1995 IPPC 2nd Assessment Report (AR2) (IPCC, 1996) were applied in line with the UNFCCC requirements for Non-Annex I Parties. Transitioning from the AR2 GWPs to AR5 GWPs led to a 2.9% and 3.7% increase in overall emissions in 2022 excluding and including LULUCF, respectively (*Table ES 2*).

The establishment of the GWP is an ongoing process, as is evident with the different values adopted in AR5 and AR6 reports, respectively. This study follows the approach stipulated in National GHG reporting guidelines, i.e. a CH_4 GWP of 23 and a N_2O GWP of 296 as well as using the AR5 GWP values to allow comparison with the latest National GHG Inventory.

The annual variation in the 2022 National GHG inventory from 2000 to 2022 (DFFE, 2025), using the AR5 100-GWP is provided in Figure 2-1. According to the final 9th National GHG Inventory Report (DFFE, 2025) the total GHG emissions in 2022 were estimated at approximately 478.30 Mt CO_2e (excluding Land Use, Land Use Change and Forestry (LULUCF)). This was a 2.2% decrease from the 2000 total GHG emissions (excluding LULUCF). LULUCF is estimated to be a net carbon sink which reduces the 2022 GHG emissions to 435.12 Mt CO_2e. The assessment (excluding LULUCF) showed the main sector contributing to GHG emissions in 2022 to be the energy sector, contributing 78% to the total GHG emissions. The table also includes the 2000 National GHG inventory values using the AR5 100-GWP for comparative purposes.

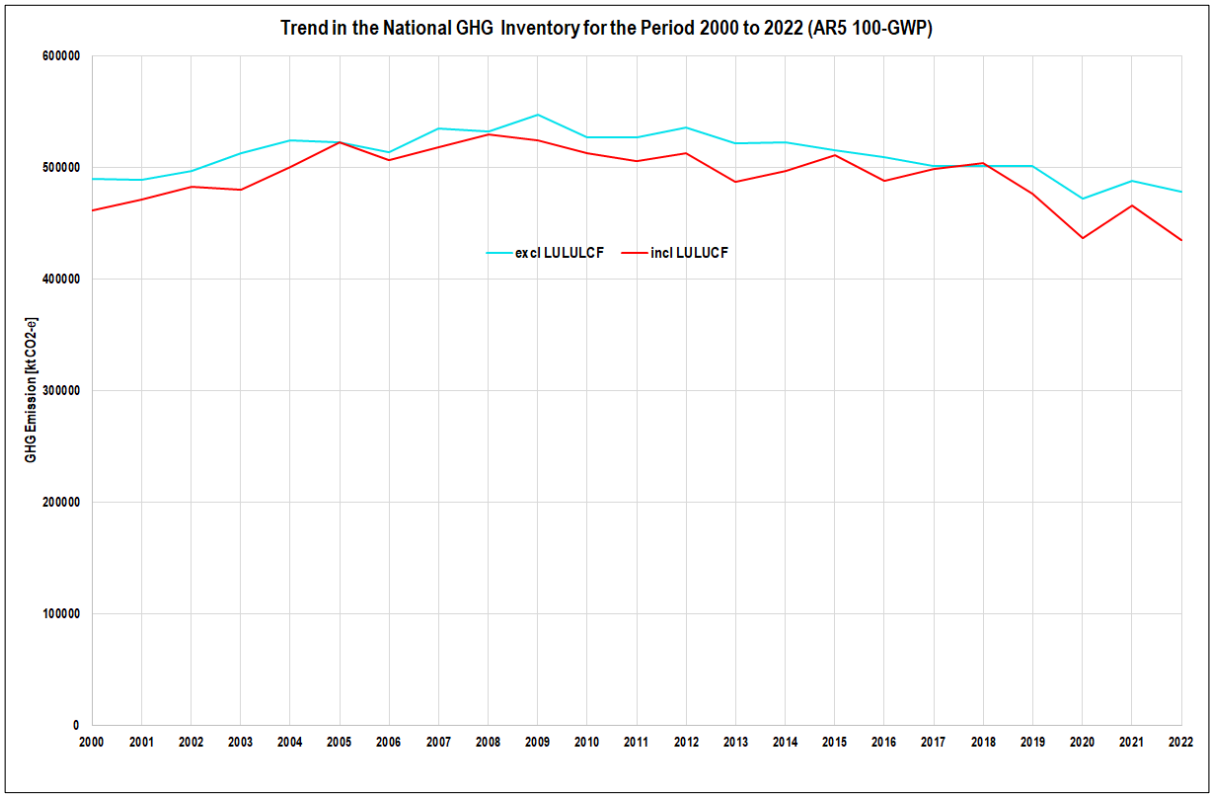


Figure 2-1: Annual trend in the South African national GHG emission inventory from 2000 to 2022 (note: FOLU is estimated to be a net carbon sink) (Source: DFFE 2025)

Energy emissions in 2022 accounted for 78.2 % (excl. LULUCF) and 86 % (incl. LULUCF) of total emissions for South Africa (**Error! Reference source not found.**). Majority of the Energy sector emissions were from Energy Industries (60 %) and Transport (14 %), while the least emissions were from Solid Fuels (0.6 %) and Oil and Natural Gas activities (0.03 %). Since 2000, Energy sector emissions decreased by 2.5 % (Table 3). Within the Energy sector, emissions from the other sectors category decreased the most (by 62%) during this period mainly because of the Residential sector. This is likely due to increased electrification over the years, as well as an increase in the use of renewable energy. Emissions from domestic aviation and petroleum refining also decreased significantly, 70% and 73% respectively since 2000. Although Energy sector emissions slightly decreased from 2000-2022 emissions from electricity production increased by 11.5% due to an 8.7% increase in power generation during that period (DFFE, 2025).

Table 2-4: National GHG emissions in South Africa for 2000 and 2022 (DFFE 2025)

Sector	2000 Emissions Inventory		2022 Emissions Inventory		Change kt CO_2-e	% Change 2000 to 2020
	GHG [kt CO_2-e]	% Contribution by Sector	GHG [kt CO_2-e]	% Contribution by Sector		
Energy	383 860.6	78.5	374 114.1	78.2	-9 746.4	-2.5
IPPU	32 781.3	6.7	30 598.0	6.4	-2 183.3	-6.7
Agriculture	58 183.7	11.9	52 890.3	11.1	-5 293.4	-9.1
LULUCF	-27 846.5		-43 181.3		-15 334.8	55.1
Waste	14 362.7	2.9	20 698.4	4.3	+6 335.7	44.1
Total (excluding LULUCF)	489 188.3	-	478 300.9	-	-10 887.4	-2.2
Total (including LULUCF)	461 341.8	-	435 119.6	-	-26 222.3	-5.7

CH_4 emissions have increased from 12.9% to 13.2% (excl. LULUCF) between 2000 and 2022. The Agriculture (specifically Enteric Fermentation) and Waste (specifically Solid Waste Disposal) sectors are the major contributors to the total CH_4 emissions in 2022.

2.5.2 GHG Emission Inventory for the Sector

The proposed project would be categorised in the industry category for both the global GHG inventory and for the national GHG inventory. According to the World Resources Institute – CAIT Climate Data Explorer[1] (as accessed in August 2026) the 2023 global GHG emissions from the industry category were approximately 3 155.57 Mt CO_2e; 6.2% of the total GHG emissions (including LULUCF). The South African industry sector contributed 15.32 Mt CO_2e, ~4% of the total South African GHG emissions and ~0.49% of the global industry sector in 2023 (Table 2-5).

Table 2-5: GHG Emissions for the Sector

Region	2023 GHG Emissions ($MtCO_2$-e)		%
	Total (including LULUCF)	Industry	Industry of total
World	50 802.9	3 155.57	6.2%
South Africa	383.8	15.32	4%

2.5.3 National Guideline for Consideration of Climate Change in Development Applications

The National Guideline for Consideration of Climate Change Implications in Applications for Environmental Authorisations, Atmospheric Emission Licenses and Waste Management Licenses was published on 24 October 2025. This guideline is a revised draft version of the first version published in June 2021, reflecting amendments based on stakeholder comments. The 2025 Draft Guideline incorporates provisions of the Climate Change Act 22 of 2024 and requires all license applicants to consider GHG emissions and climate risks. It also mandates the

[1] http://cait.wri.org/ and Data Explorer | Climate Watch

development of practical adaptation measures to cope with future climate conditions. The guideline was open for public comment until 24 November 2025.

The National Guideline has been developed to support the inclusion of climate change considerations into the Environmental Impact Assessment (EIA) process, and to create a consistent approach for such incorporation, which will help proponents to assess:

- how a proposed development will likely exacerbate climate change;
- the impact of a development on features (natural and built) that are crucial for climate change adaptation and resilience; and,
- the sustainability of a development in the context of climate change projection.

The Guideline puts forward "a consistent approach in providing interested and affected parties (for example, proponents, Environmental Assessment Practitioners (EAPs) and specialists) with the minimum requirements to consider when undertaking a climate change assessment, which forms part of an application for environmental authorisation, an atmospheric emissions licence, and/or waste management licence".

One of the impact requirements for a climate change assessment is an estimation of the GHG emissions, direct and indirect (including upstream GHG emissions) that will be released into the atmosphere annually throughout the impact related to the activity.

3 PHYSICAL RISKS OF CLIMATE CHANGE ON THE REGION

The discussions of physical risks of climate change discussed in this section are likely to be relevant to the project as well as to the communities surrounding the project even if the project is not authorised.

3.1 Vulnerability

The Green Book (CSIR, 2019); was developed to be an online platform providing quantitative scientific evidence on the likely impacts that climate change and urbanisation will have on South Africa's cities and towns. A profile for each local municipality, including individual settlements and neighbourhoods, was built in terms the rates of socio-economic, economic, physical and environmental risks associated with urbanisation, population growth and climate change (Le Roux, et al., 2019). The risk profile was accessed for the Merafong City Local Municipality[2].

Six (6) composite indicators are accounted for allowing investigation of the relative vulnerabilities of settlements within a specific local municipality. A high vulnerability score (closer to 10) indicates a scenario where an undesirable state is present; e.g. low access to services, high socio-economic vulnerabilities, poor regional connectivity, environmental pressure or high economic pressures.

The vulnerability of Deelkraal Gold Mine 1 and 2 are visually demonstrated in Figure 3-1, with a more detailed description of four of the indicators provided.

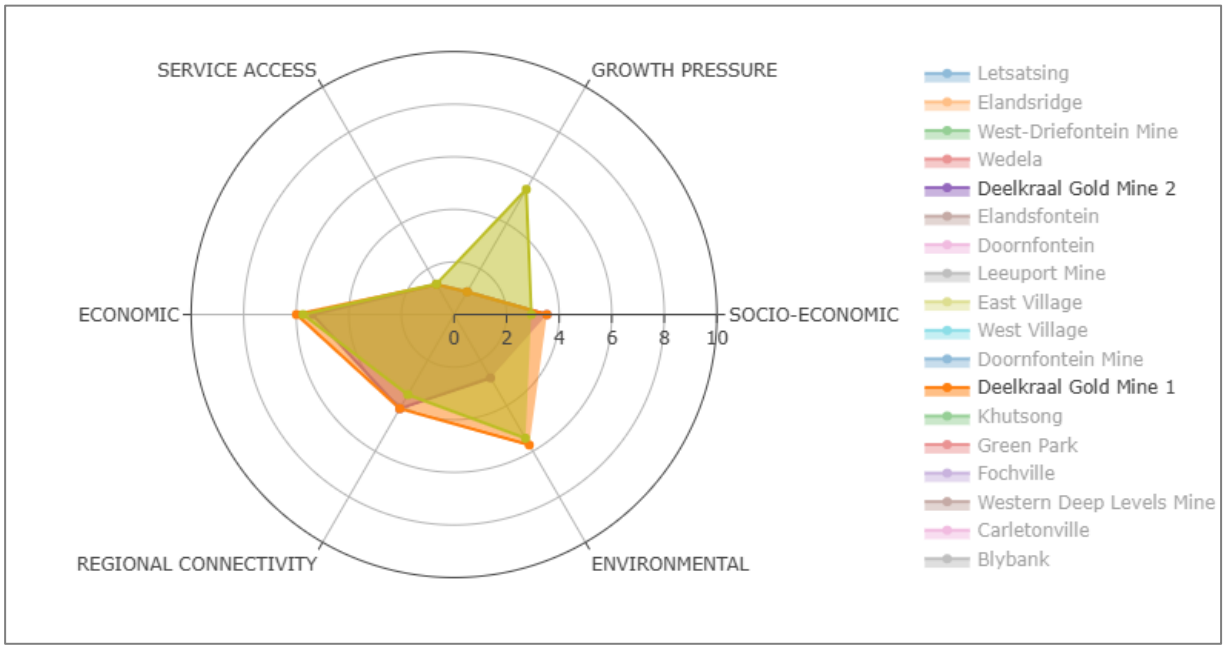


Figure 3-1: Visual display of the Deelkraal Gold Mine 1 and 2 vulnerabilities

2 https://riskprofiles.greenbook.co.za/. The indicator measures air quality, environmental governance, and the competition between the ecology and urban encroachment. An indicator of growth pressure, providing a temporal dimension (15-year trend), was added to show the user which settlements are experiencing growth pressures on top of the other dimensional vulnerabilities.

Socio-economic: The Merafong City Local Municipality socio-economic vulnerability score[3] (out of 10) is 3.0 for 1996, increasing to 4.2 for 2011 and 4.5 for 2022. The higher vulnerability score (closer to 10) in 2022 indicates a higher number of vulnerable households with regards to household composition, education and health, access to basic services, and safety and security. The Merafong City Local Municipality ranks 8th out of 22 in the province and 53rd out of 213 in the country. For the future scenario (2050) the population is predicted to decrease by 59% based on medium growth scenario, from 197 484 in 2011 to 116 181 people in 2050.

Economic: The Merafong City Local Municipality economic vulnerability score[4] (out of 10) is 1.0 for 1996, increasing to 4.9 for 2011 then decreasing to 2.6 in 2022. The lower economic vulnerability score in 2022 compared to 2011 indicates a lower susceptibility to external shocks based on the economic diversity, size of the economy, labour force, GDP growth rate and the inequality present in the municipality. The economic vulnerability[5] ranks 1st out of 9 in the province and 53rd out of 213 in the country, thus a low vulnerability.

Physical: The Merafong City Local Municipality physical vulnerability score[6] (out of 10) is 2.4 in 2022, which ranks 2nd out of 9 in the province and 11th out of 213 in the country. A high physical vulnerability score (closer to 10) highlights areas of remoteness and/or areas with structural vulnerabilities, thus the municipality has a low physical vulnerability.

Environmental: The Merafong City Local Municipality environmental vulnerability score[7] (out of 10) is 4.5 in 2022, with no scores provided for 1996 or 2011. The total provincial score is 3rd out of 9 and 136th out of 213. A high score (closer to 10) reflects much conflict between preserving the environment and allowing land-use changes to occur. Based on this, the Municipality has a moderate environmental risk.

3 Defined as the vulnerability of households based on household composition; education and health; access to basic services; safety and security. An indicator of growth pressure, providing a temporal dimension (15-year trend), was added to show the user which settlements are experiencing growth pressures on top of the other dimensional vulnerabilities.

4 Defined as the susceptibility of the municipality to external shocks based on economic diversity; size of economy; labour force; gross domestic product (GDP) growth rate; and inequality.

5 The higher the economic vulnerability (closer to 10) the more susceptible the municipality is to external shocks based on the economic diversity, size of the economy, labour force, GDP growth rate and the inequality present in the municipality.

6 Physical vulnerability addresses the physical fabric and connectedness of the settlements in the local municipality. A high physical vulnerability score (closer to 10) highlights areas of remoteness and/or areas with structural vulnerabilities.

7 An indicator representing the conflict between preserving the natural environment and accommodating the growth pressures associated with population growth, urbanisation and economic development.

Defined as the susceptibility of the municipality to external shocks based on economic diversity; size of economy; labour force; gross domestic product (GDP) growth rate; and inequality.

3.2 Climate

3.2.1 Baseline Climate

Climate change metrics focus on temperature; the number of very hot days (where the maximum temperatures exceed 35°C); rainfall and extreme rainfall events (more than 20 mm of rain occurring within 24 hours). The baseline (1961 to 1990) annual averages for these metrics were accessed for the area near the project site from the South Africa 'Green Book'[8] (CSIR, 2019). The metrics include three percentiles[9] (10th, 50th, and 90th) as an indication of the variability within the measured data set.

Baseline annual average temperature was in the range 9.9°C (minimum) and 22.7°C (maximum) (Figure 3-2) with the number of very hot days[10] at 0.9 days per year (**Error! Reference source not found.**). Heat wave days for the area, where the maximum temperature exceeds the average maximum temperature of the warmest month of the year at that location by 5°C, for a period of at least three consecutive days is given as 4.1 days (Figure 3-4). The annual average rainfall is 911 mm (Figure 3-5).

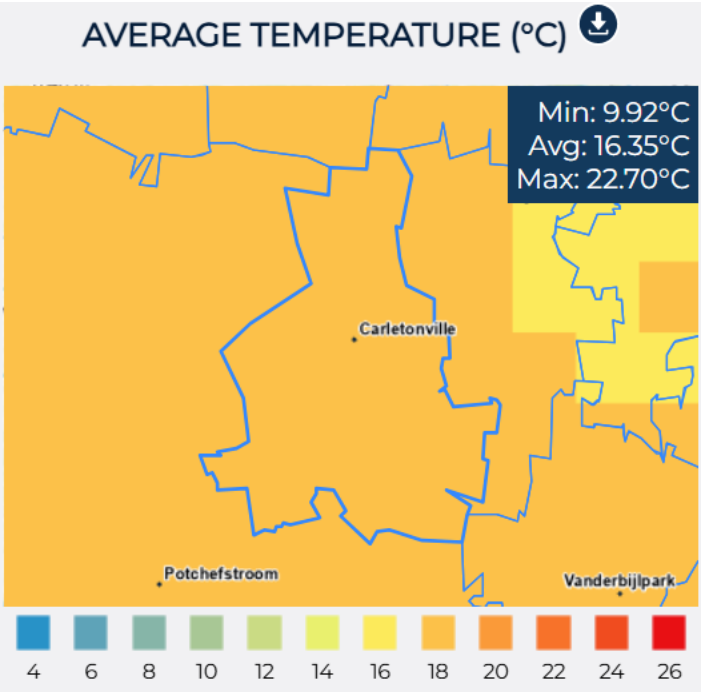


Figure 3-2: Baseline (1961 to 1990) annual average temperature for the project area (CSIR, 2019)

[8] https://greenbook.co.za/

[9] A percentile is a statistical measure to indicate the value below which a given percentage of observations in a group of observations falls. For example, the 90th percentile is the value below which 90% of the observations fall. The 10th percentile is the value below which 10% of the observations fall.

[10] The very hot days map depicts the number of days (per 8 x 8 km grid point) where the maximum temperature exceeds 35°C.

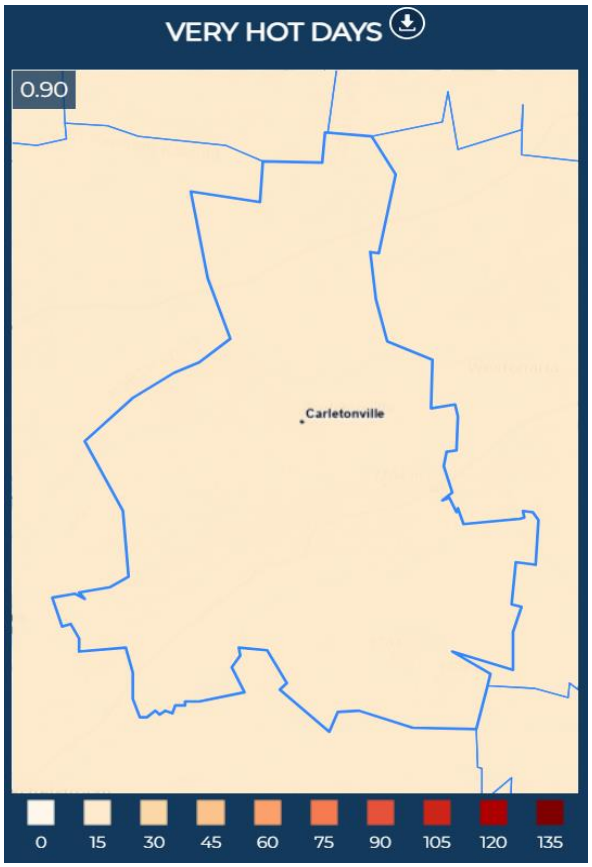


Figure 3-3: Baseline (1961 to 1990) number of very hot days (>35°C) annually for the project area (CSIR, 2019)

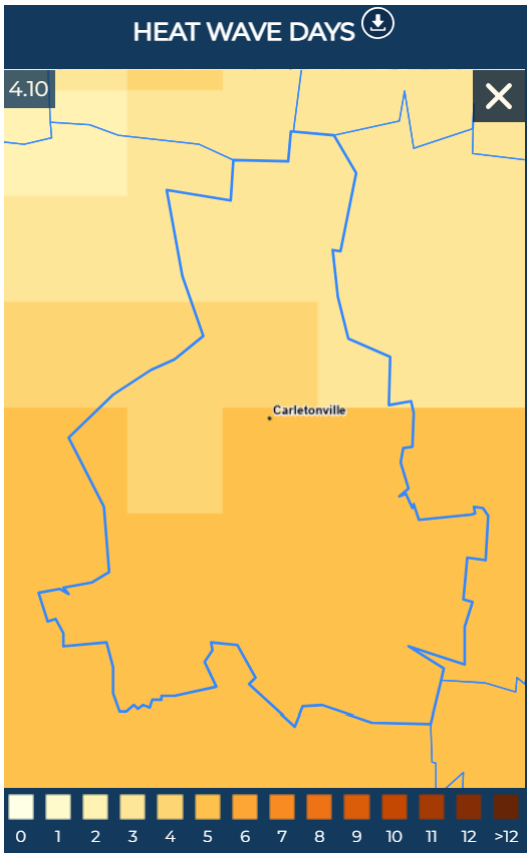


Figure 3-4: Baseline (1961 to 1990) annual average heat wave days for the project area (CSIR, 2019)

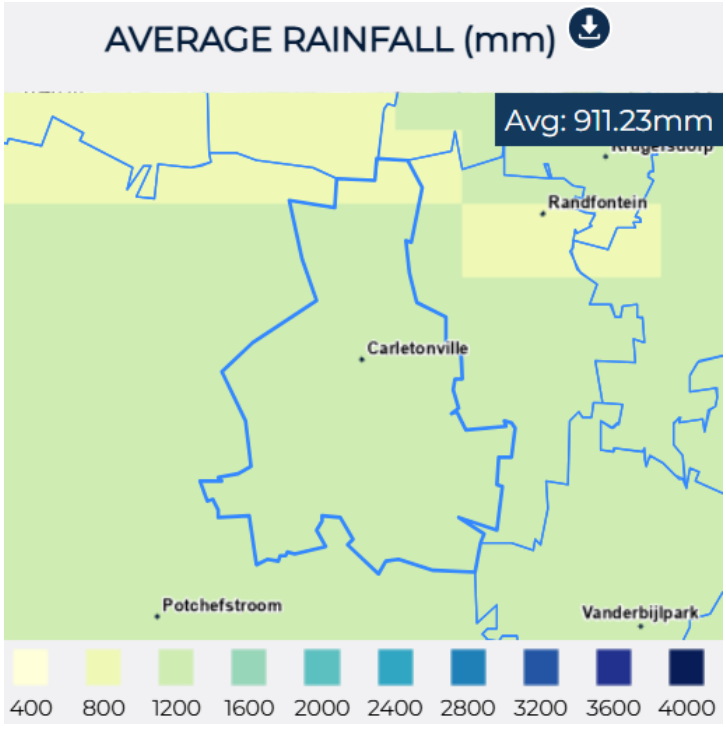


Figure 3-5: Baseline (1961 to 1990) annual average rainfall for the project area (CSIR, 2019)

3.2.2 Projected Future Climate

In 2017 the South African Weather Services (SAWS) published an updated Climate Change Reference Atlas (CCRA) based on Global Climate Change Models (GCMs) projections (SAWS, 2017). It must be noted that as with all atmospheric models there is the possibility of inaccuracies in the results because of the model's physics and accuracy of input data. The Rossby Centre regional model (RCA4) was used in the predictions for the CCRA which included the input of nine GCMs results. The RCA4 model was used to improve the spatial resolution to 0.44° x 0.44°- the finest resolution GCMs in the ensemble were run at resolutions of 1.4° x 1.4° and 1.8° x 1.2°. Findings from downscaled climatic simulations using six GCMs, at an 8 km x 8 km resolution over South Africa, for the time slab 2021 to 2050 were included in the Green Book (Engelbrecht, 2019).

In both the CCRA and the Green Book, two trajectories are included based on the four Representative Concentration Pathways (RCPs) discussed in the IPCC's fifth assessment report (AR5) (IPCC, 2013). RCPs are defined by their influence on atmospheric radiative forcing in the year 2100. RCP4.5 represents an addition to the radiation budget of 4.5 W/m^2 as a result of an increase in GHGs. The two RCPs selected were RCP4.5 representing the medium-to-low pathway and RCP8.5 representing the high pathway. RCP4.5 is based on a CO_2 concentration of 560 ppm and RCP8.5 on 950 ppm by 2100. RCP4.5 is based on if current interventions to reduce GHG emissions being sustained (after 2100 the concentration is expected to stabilise or even decrease). RCP8.5 is based on if no interventions to reduce GHG emissions being implemented (after 2100 the concentration is expected to continue to increase).

3.2.2.1 RCP4.5 Trajectory

The Green Book projected temperature changes in the near future (2021 to 2050) indicate a 10th percentile increase of 2.2°C and a 90th percentile increase of 2.8°C with a 50th percentile of 2.3°C (Figure 3-6). The number of very hot days are expected to increase to 6 days per year (50th percentile) and up to 19.6 days per year (90th percentile) (Figure 3-7). Between 2021 and 2050 the annual rainfall near the project site is projected to increase by 71 mm (50th percentile) (Figure 3-8), with extreme rainfall days potentially showing a 1.1 day increase (50th percentile) in the near future (Figure 3-9).

3.2.2.2 RCP8.5 Trajectory

The Green Book projected temperature changes in the near future (2021 to 2050) indicate a 50th percentile increase of 2.7°C and a 90th percentile increase of 3.2°C (Figure 3-6). The number of very hot days are expected to increase to 24.5 days per year (90th percentile) (Figure 3-7). Between 2021 and 2050 the annual rainfall near the project site is projected to increase by 114 mm (50th percentile) (Figure 3-8), with extreme rainfall days potentially showing an increase of 1.6 days (90th percentile) in the near future (Figure 3-9).

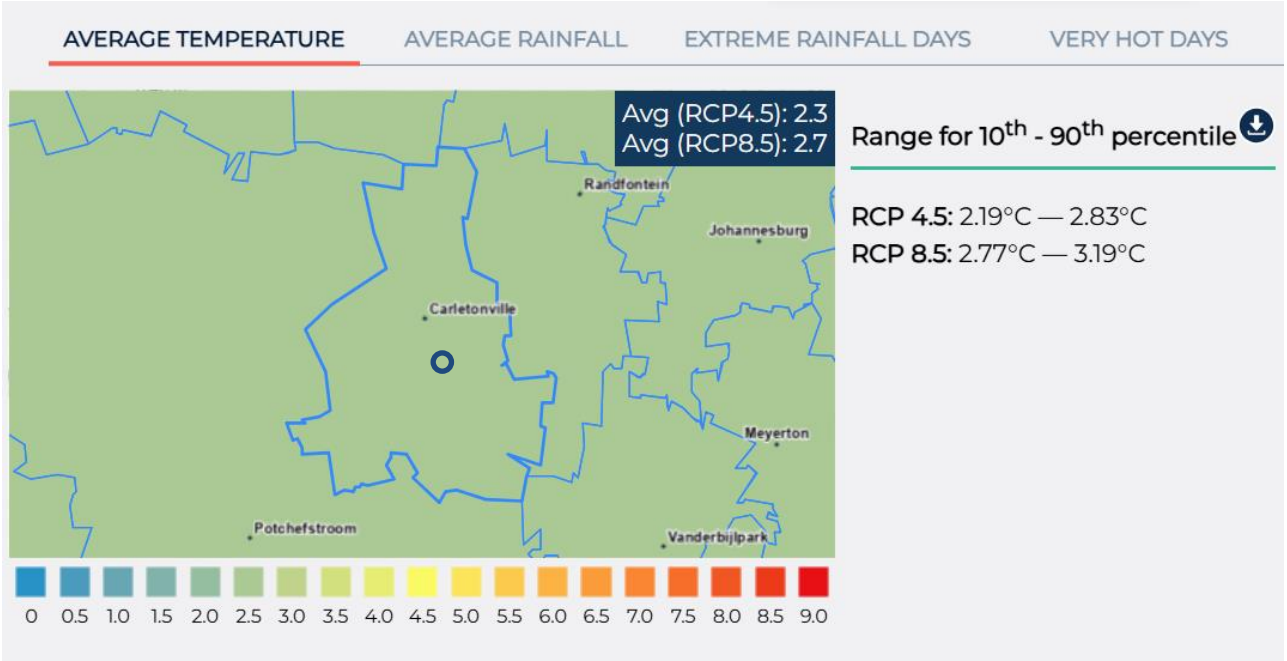


Figure 3-6: Projected change in annual average temperature for the near future (2021 – 2050)

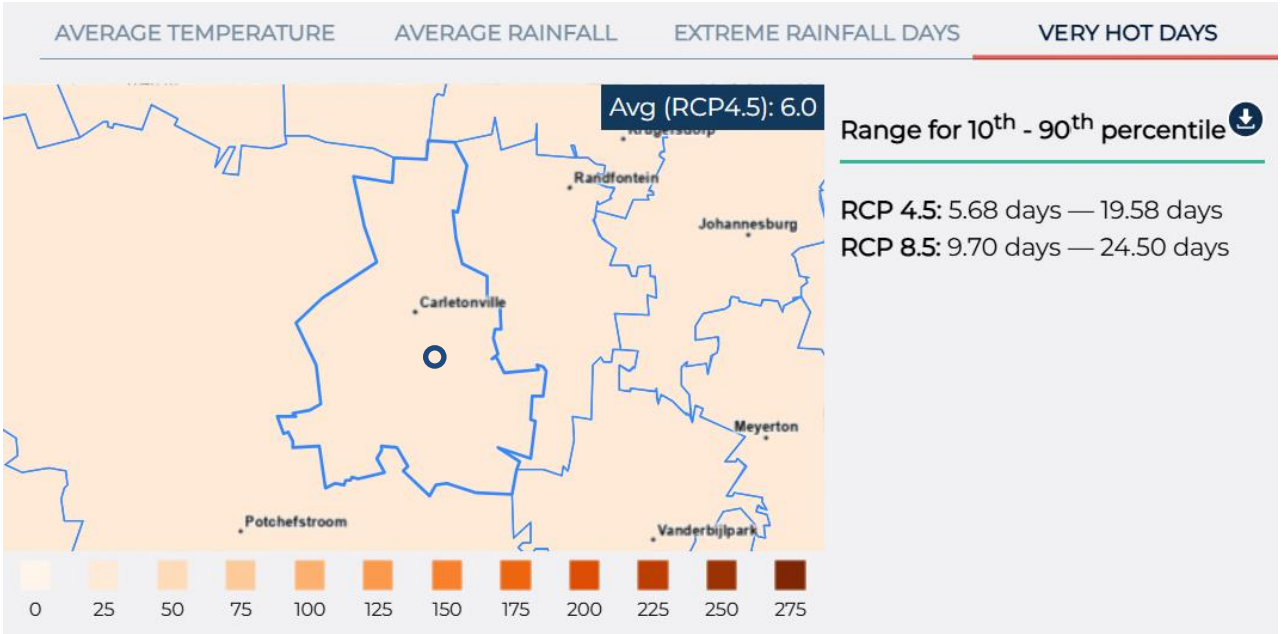


Figure 3-7: Projected change in very hot days for the near future (2021 – 2050)

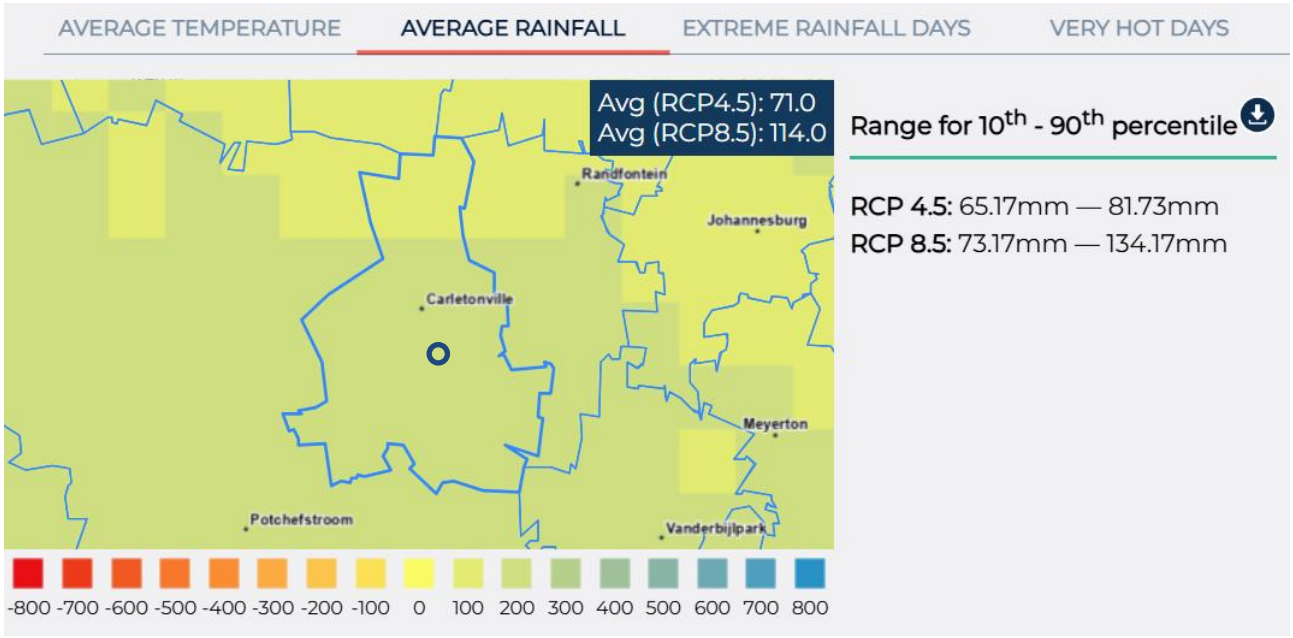


Figure 3-8: Projected change in annual average rainfall for the near future (2021 – 2050)

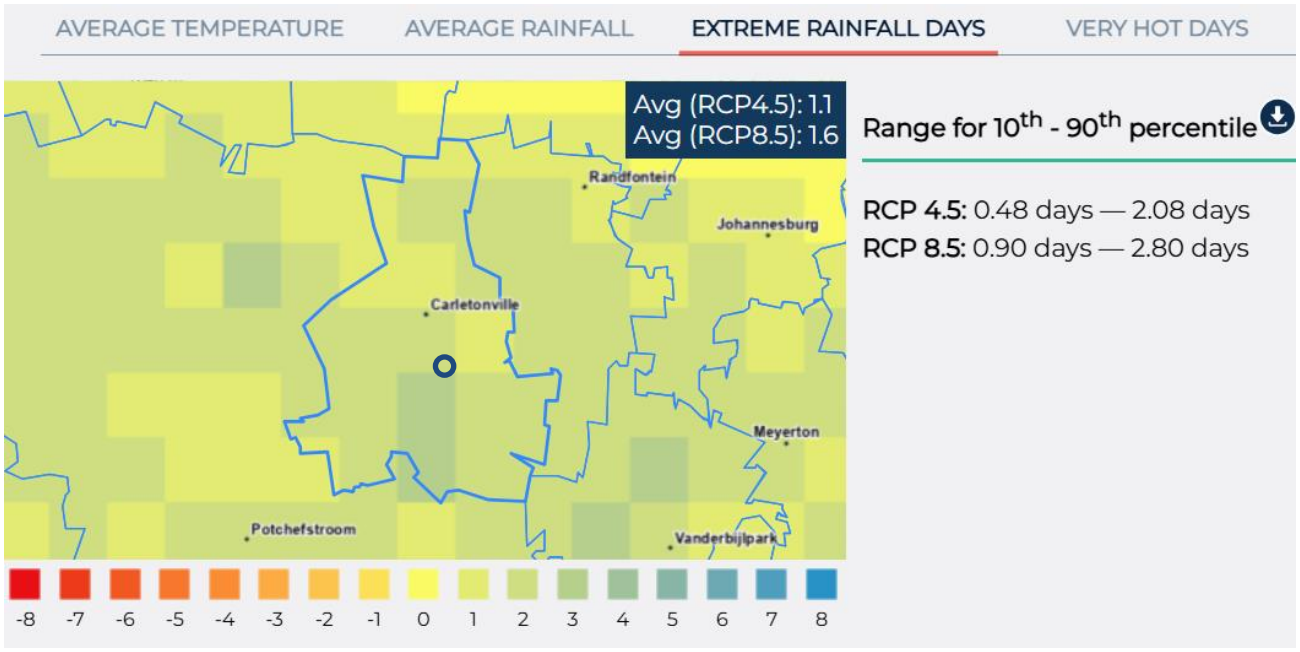


Figure 3-9: Projected change in annual average number of extreme rainfall days (>20 mm in <24 hours)

3.2.2.3 IPCC's Sixth Assessment Report: Temperature and Rainfall Projections

The most recent IPCC data are from the Coupled Model Intercomparison Project (CMIP) which were derived from the sixth phase of the CMIPs (CMIP6) and supports the IPCC's Sixth Assessment Report (AR6) that was released on 9 August 2021 (Working Group I), 28 February 2022 (Working Group II and 4 April 2022 (Working Group III). Projection data is presented at a 1.0º x 1.0º (100 km x 100 km) resolution. The scenarios are the result of complex calculations that depend on how quickly humans curb greenhouse gas emissions, whilst also capturing socioeconomic changes in areas such as population, urban density, education, land use and wealth. For example, a rise in population is assumed to lead to higher demand for fossil fuels and water. Education can affect the rate of technology developments. Emissions increase when land is converted from forest to agricultural land. Each scenario is labelled to identify both the emissions level and the so-called Shared Socioeconomic Pathway, or SSP, used in those calculations. This first scenario is the only one that meets the Paris Agreement's goal of keeping global warming to around 1.5°C above preindustrial temperatures, with warming hitting 1.5°C but then dipping back down and stabilizing around 1.4°C by the end of the century. Projected changes are defined relative to a historical 20-year period (1995 to 2014).

The AR6 projections for the study area for the scenario RCP4.5 indicate an increase in annual average temperatures of 1.8°C for the period 2041 to 2060 and 2.6°C for the period 2081 to 2100. The projections for the RCP8.5 indicate an increase in annual average temperatures of 2.4°C for the period 2041 to 2060, to 5.3°C for the period 2081 to 2100 (IPPC, 2022).

The AR6 projections for rainfall in the study area for RCP4.5 indicate an increase in annual rainfall of 1.5 mm/day for the period 2041 to 2060, and an increase of 2.2 mm/day for the RCP8.5 (IPPC, 2022). The projections for 2081 to 2100 indicate an increase in annual rainfall of 1.3 mm/day for the RCP4.5 scenario and an increase in annual rainfall of 1.9 mm/day for the RCP8.5.

3.3 Hazards

The Green Book risk profile includes an assessment of projected risk to the Merafong City Local Municipality in 2050, mostly based on the low mitigation RCP8.5 climate simulations, and highlights the following:

- For 2050 there is a 28 day increase in fire danger days over the project area, with a high potential in exposure to wildfires (Figure 3-10);
- There is an increase in drought tendencies (i.e. the number of cases exceeding near-normal per decade) for the period 2035–2064 relative to the 1986–2005 baseline period. The Standardized Precipitation Index (SPI)[12] is -0.90 (Figure 3-11). A negative value is indicative of an increase in drought tendencies per 10 years (more frequent than baseline) although the potential in exposure to drought is Low (Figure 3-11);
- The settlements near the project area are at Medium risk of encountering increasing heat stresses (Figure 3-12); and,

12 The Standardized Precipitation Index (SPI) is a widely used index to characterize meteorological drought on a range of timescales. SPI index.

- There is no significant increase in extreme daily rainfall for the project area (1.039)[13] with a Moderate potential increase in exposure to flooding (Figure 3-13).

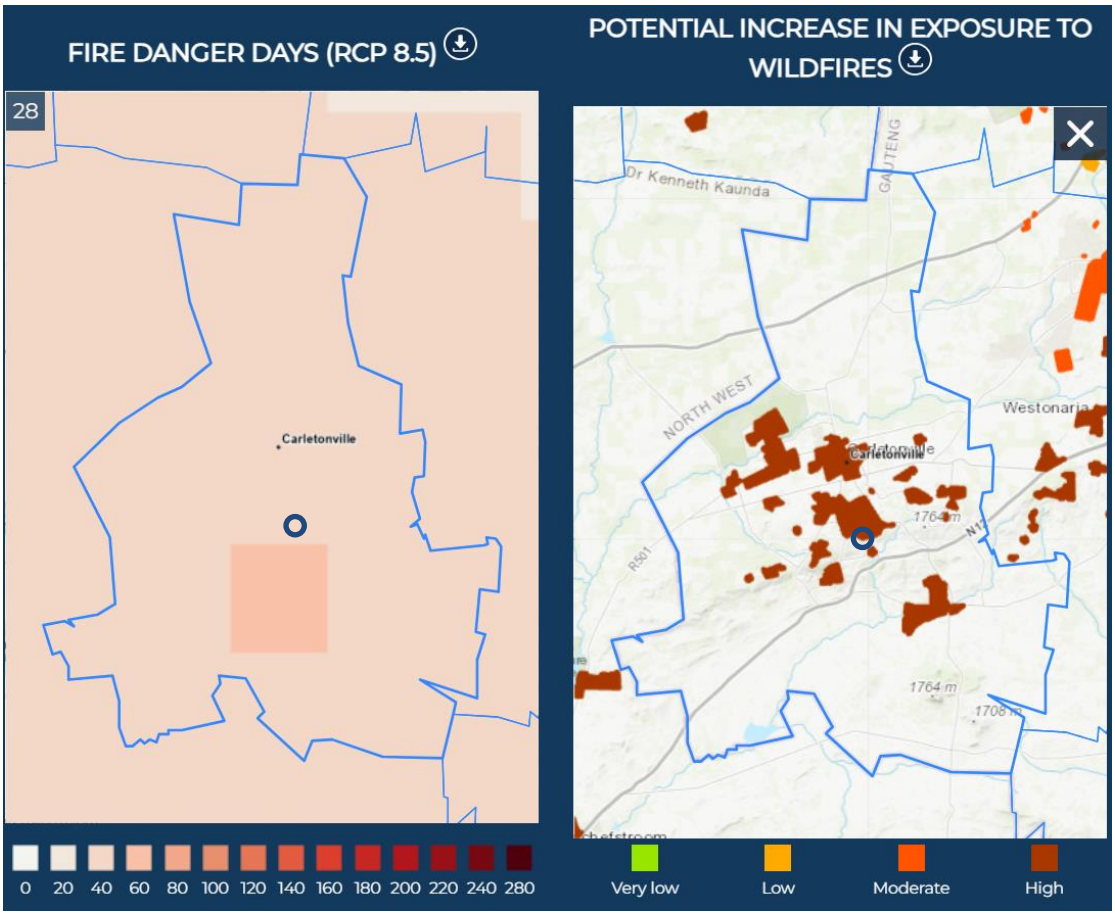


Figure 3-10: Risk of increased wildfires for Merafong City Local Municipality in 2050 based on RCP8.5 trajectory (dark blue marker indicates approximate location of the project)

[13] A value of more than 1 indicates an increase in extreme daily rainfalls.

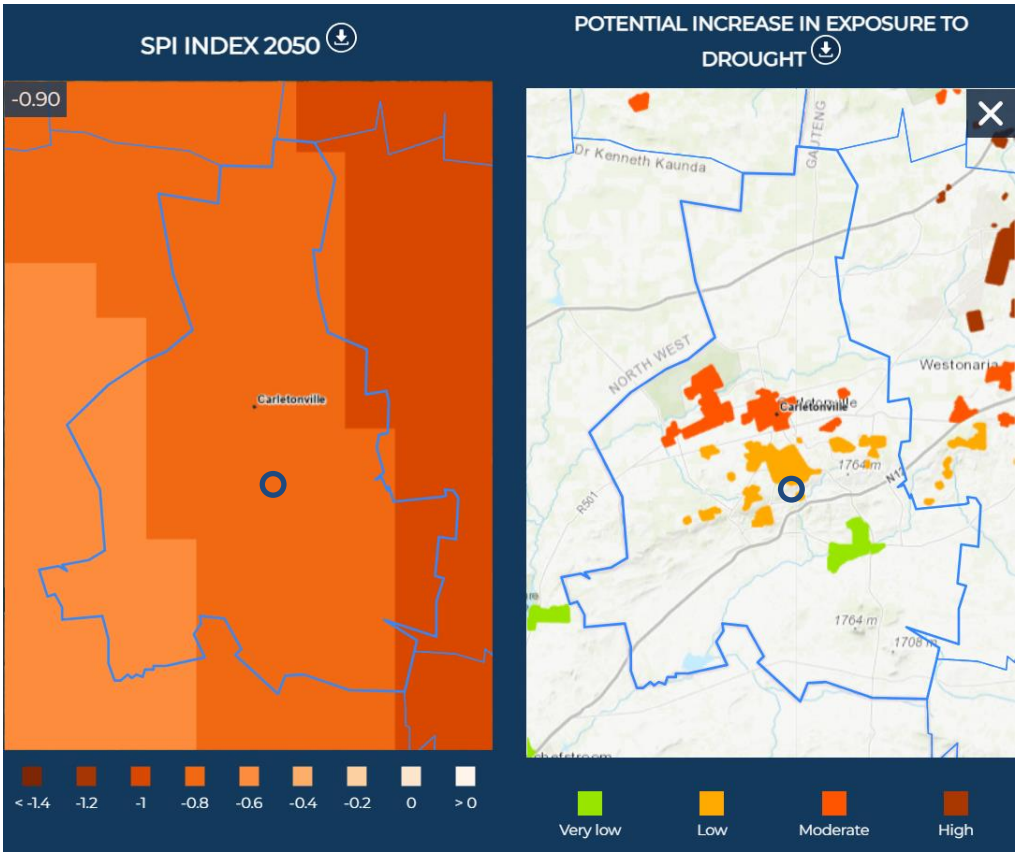


Figure 3-11: Risk of increased drought tendencies for Merafong City Local Municipality in 2050 based on RCP8.5 trajectory (dark blue marker indicates approximate location of the project)

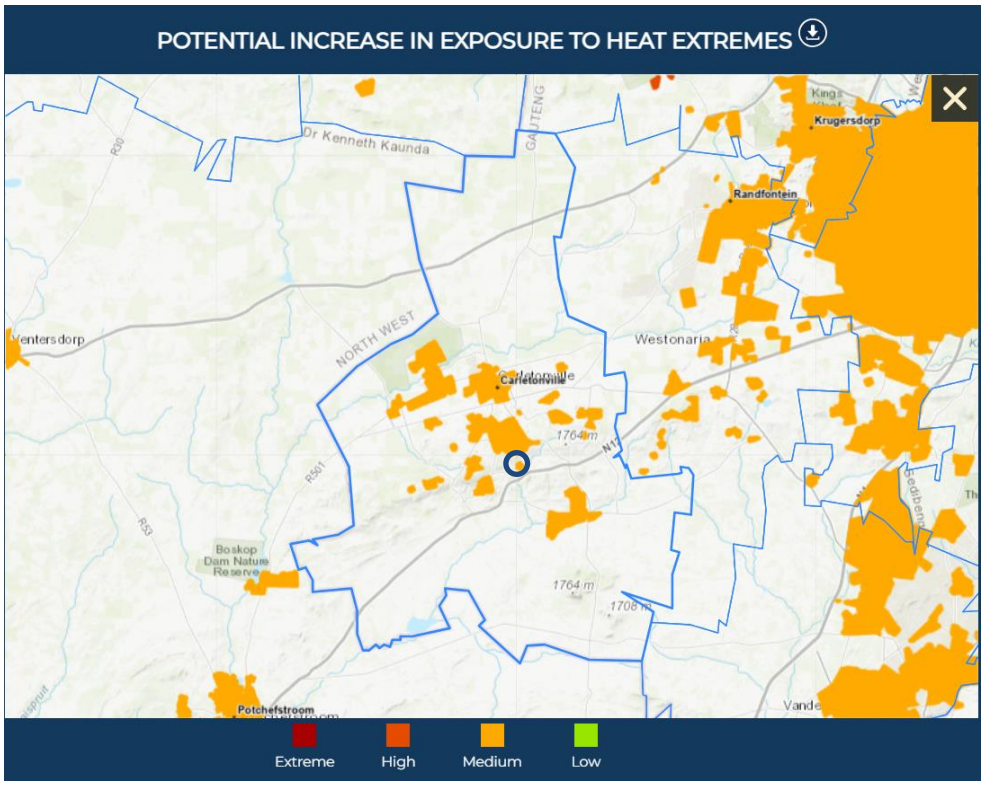


Figure 3-12: Risk of increased heat extremes for Merafong City Local Municipality in 2050 based on RCP8.5 trajectory (dark blue marker indicates approximate location of the project)

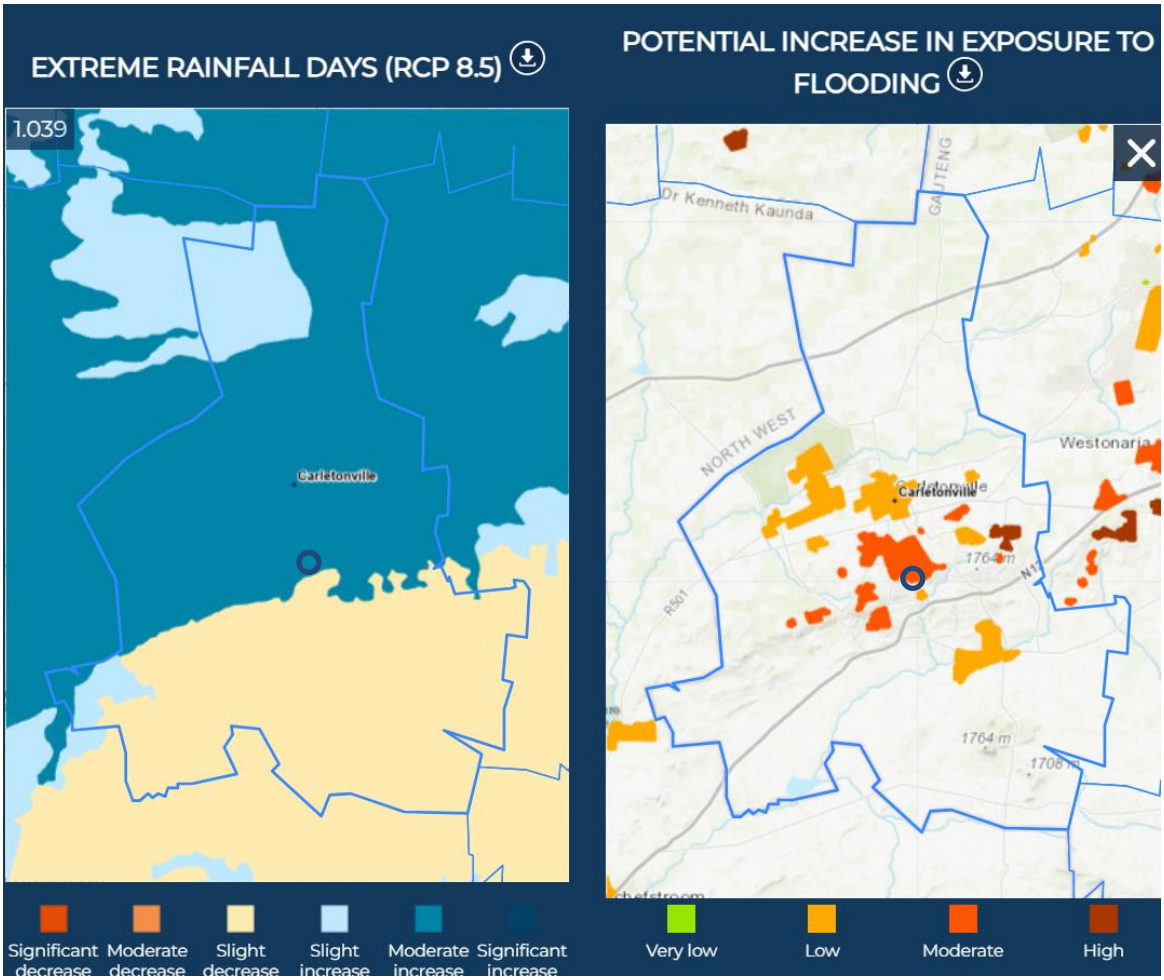


Figure 3-13: Risk of increased flooding for Merafong City Local Municipality in 2050 based on RCP8.5 trajectory (dark blue marker indicates approximate location of the project)

3.4 Impact of Climate Change

To understand the impact that climate change might have on the major resources of the Merafong City Local Municipality it is first necessary to provide an overview of the current situation, which has been provided for water, economy, and agriculture.

3.4.1 Water Supply

3.4.1.1 Current Resources

Figure 3-14 provides the current water supply vulnerability (i.e., demand versus supply) for the Merafong City Local Municipality based on the data compiled for the Department of Water and Sanitation (DWS) All Town's Study (Cole, Bailey, Cullis, & New, 2017). There was no surface water or ground-water usage information available, as shown in Figure 3-14.

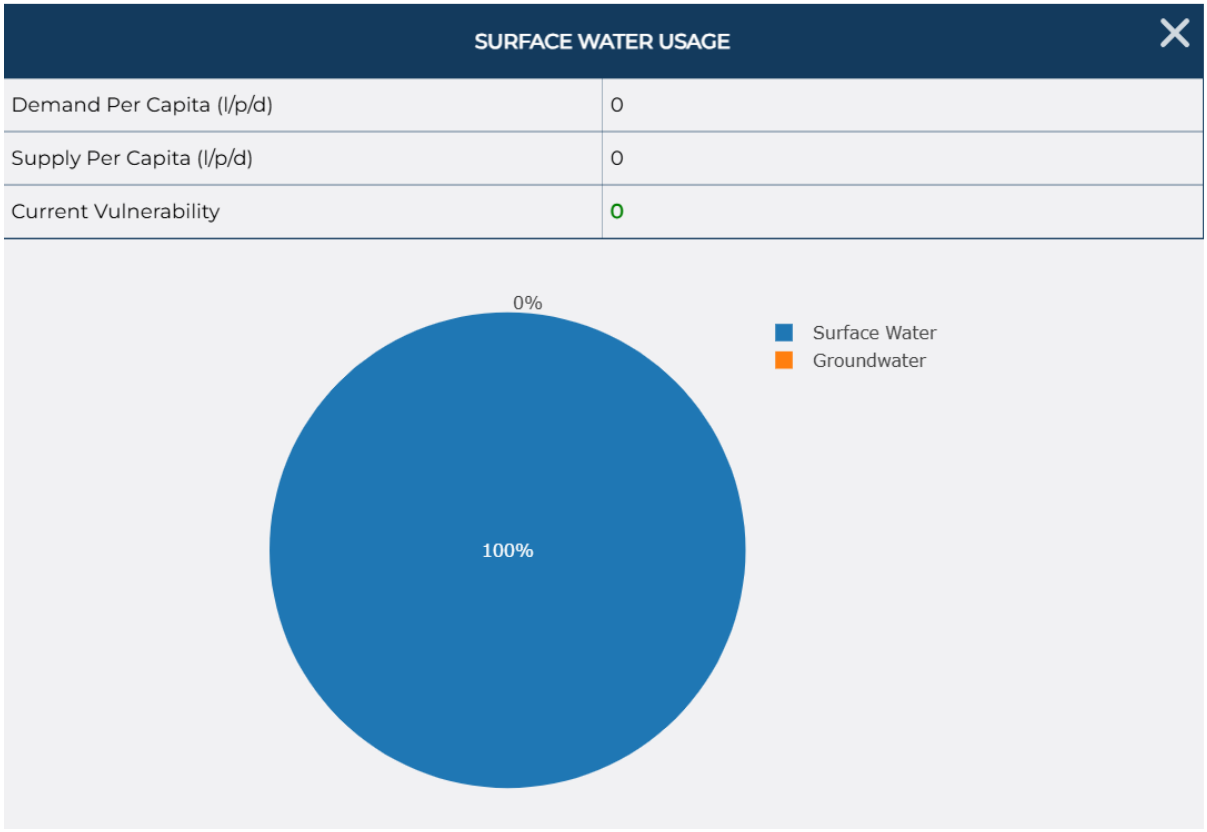
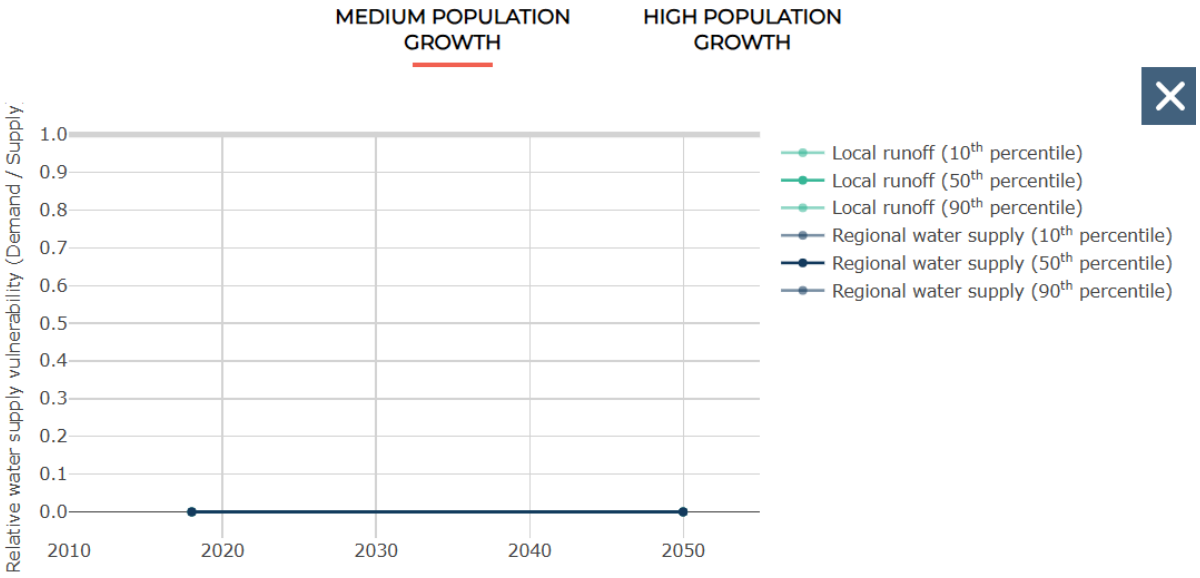


Figure 3-14: Current water availability for the Merafong City Local Municipality (insufficient information available)

3.4.1.2 Impact on Resources

Figure 3-15 shows the estimated current and future water supply vulnerability (i.e., the ratio of demand to supply) based on: 1) a local water supply perspective incorporating changes to population growth coupled with exposure to climate risk (based on impacts on local runoff), and 2) a regional water supply perspective (based on impacts of regional water supply assuming supply is part of the integrated regional and national bulk water supply network). The mean annual precipitation for the municipality is predicted to decrease by 1% for 2050 with a regional urban water supply increase of 0%.



VULNERABILITY CONTRIBUTION FACTORS		PERCENTAGE CHANGE
Mean annual precipitation	▲	1%
Mean annual evaporation	▲	10.44%
Mean annual runoff	▲	44.05%
Regional urban water supply	-	0%
Population growth	▼	-50.97%

Figure 3-15: Estimated current and future (2050) water supply vulnerability based on medium population growth for the Merafong City Local Municipality

3.4.2 Surface Water

3.4.2.1 Current Situation

Figure 3-16 depicts the current annual and monthly surface water runoff, precipitation and evaporation for the Primary Catchment associated with the Merafong City Local Municipality. Average precipitation and evaporation for the municipality is currently 626 mm/yr (which is lower than the 911 mm/yr referenced for the site in Section 3.2.1) and 1 680 mm/yr respectively.

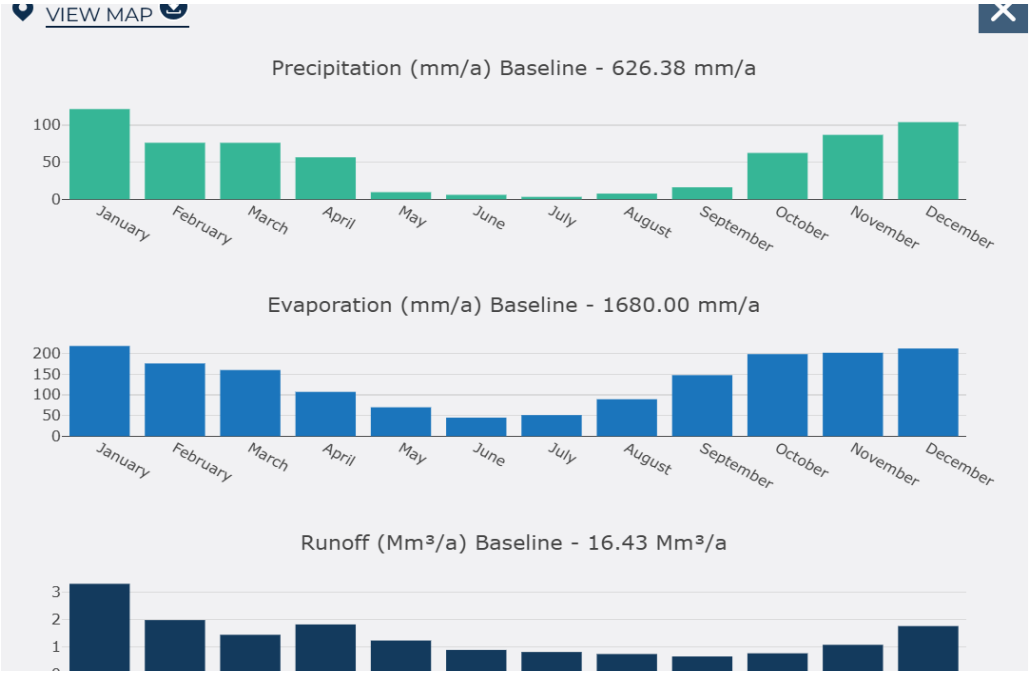


Figure 3-16: Current annual and monthly surface water runoff, precipitation and evaporation for the Merafong City Local Municipality which falls under the Gauteng Primary Catchment

3.4.2.2 Projected Impact

Figure 3-17 provides the projected monthly change for future (2050) evaporation, precipitation, and estimated runoff values. It should be noted that these projections differ rom the Greenbook projections (see Section 3.2.2).

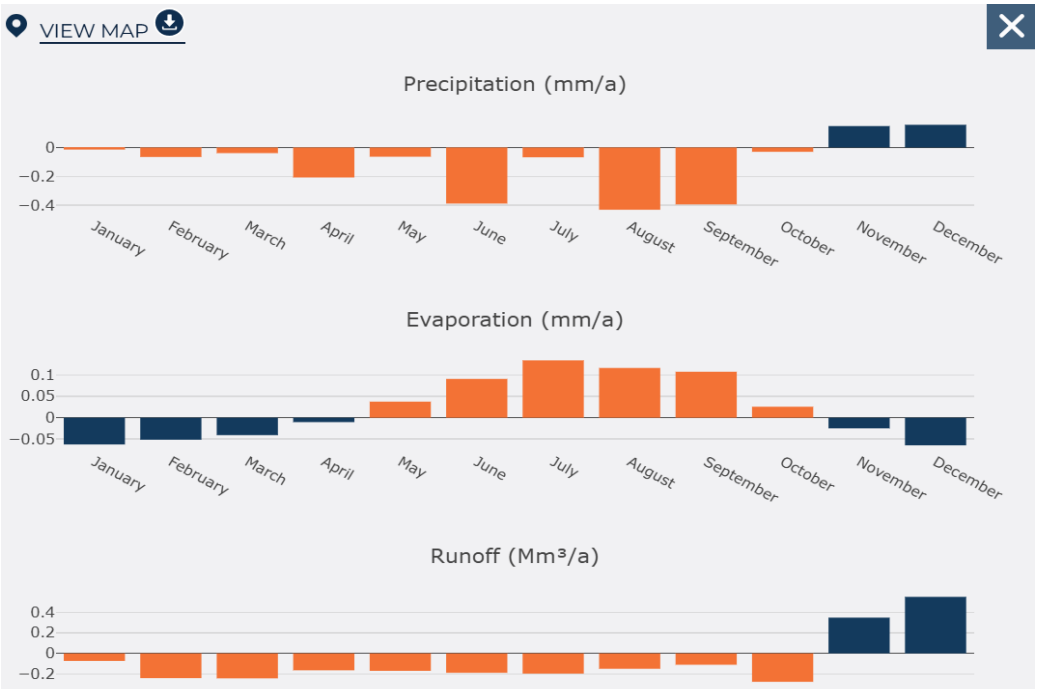


Figure 3-17: Projected monthly change to future (2050) evaporation, precipitation, and estimated runoff values

3.4.3 Ground Water

3.4.3.1 Current Situation

The groundwater recharge potential map indicates the occurrence and distribution of groundwater resources across the municipality, showing distinctive recharge potential zones. The groundwater dependency map indicates where settlements get their main water supply from, be it groundwater, surface water or a combination of both sources. Settlements that rely on groundwater, either entirely or partially, are deemed groundwater dependent (Figure 3-18).

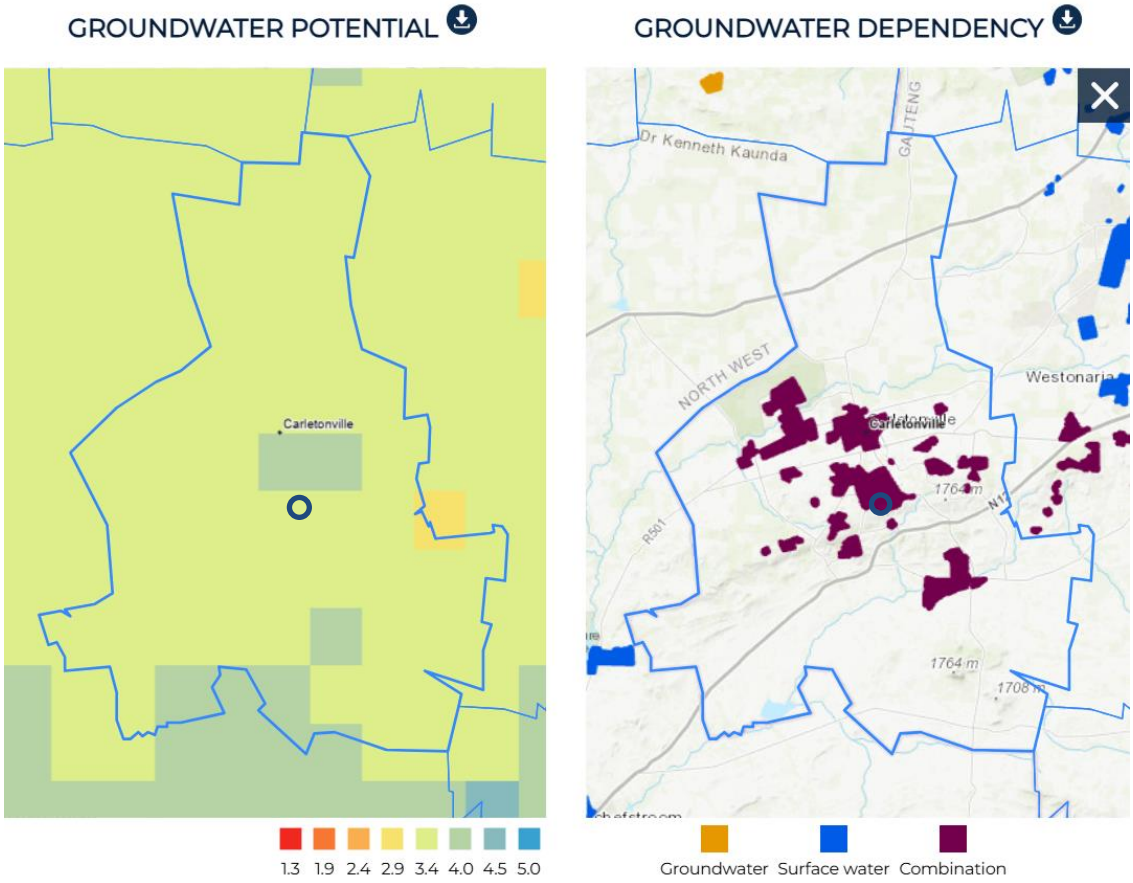


Figure 3-18: Groundwater potential and dependency for the Merafong City Local Municipality (dark blue marker indicates approximate location of the project)

3.4.3.2 Projected Impact

A groundwater depletion risk map was created to determine which of South Africa's groundwater dependent settlements may be most at risk to groundwater depletion based on decreasing groundwater aquifer recharge potential and significant increases in population growth pressure by 2050. The groundwater depletion risk map (Figure 3-19) is based on the settlement aquifer recharge potential of the 50th percentile RCP8.5 scenario, and the medium population growth scenario. There is no change to groundwater potential in the project area.

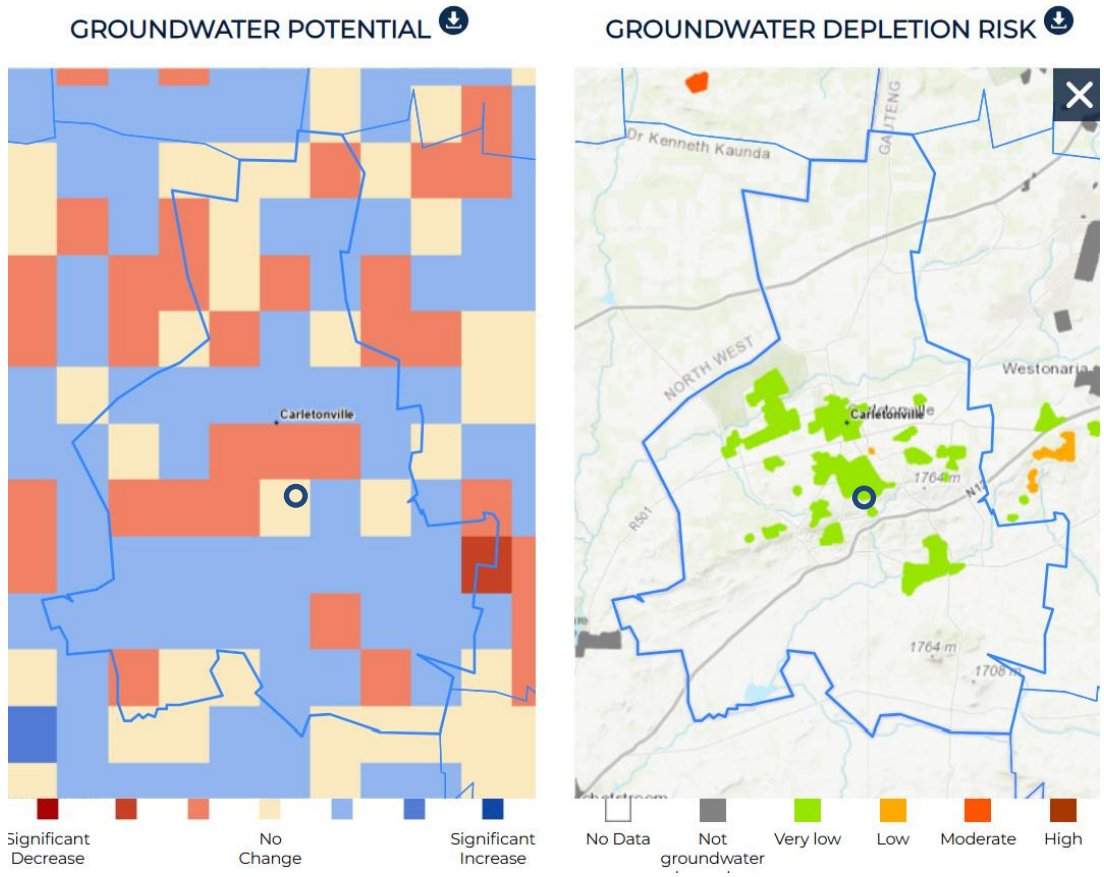


Figure 3-19: Groundwater potential and depletion for 2050 for the Merafong City Local Municipality (dark blue marker indicates approximate location of the project)

3.4.4 Economy

Figure 3-20 shows the contribution that the different economic sectors make to the total Gross Value Added (GVA)[14] of the Merafong City Local Municipality as well as its national GVA rank (total GVA contribution to the national GVA). The Merafong City Local Municipality ranks 25th in the national GVA rank with a predominant contribution from the mining and quarrying sector.

[14] Gross value added (GVA) is an economic productivity metric that measures the contribution of a corporate subsidiary, company, or municipality to an economy, producer, sector, or region.

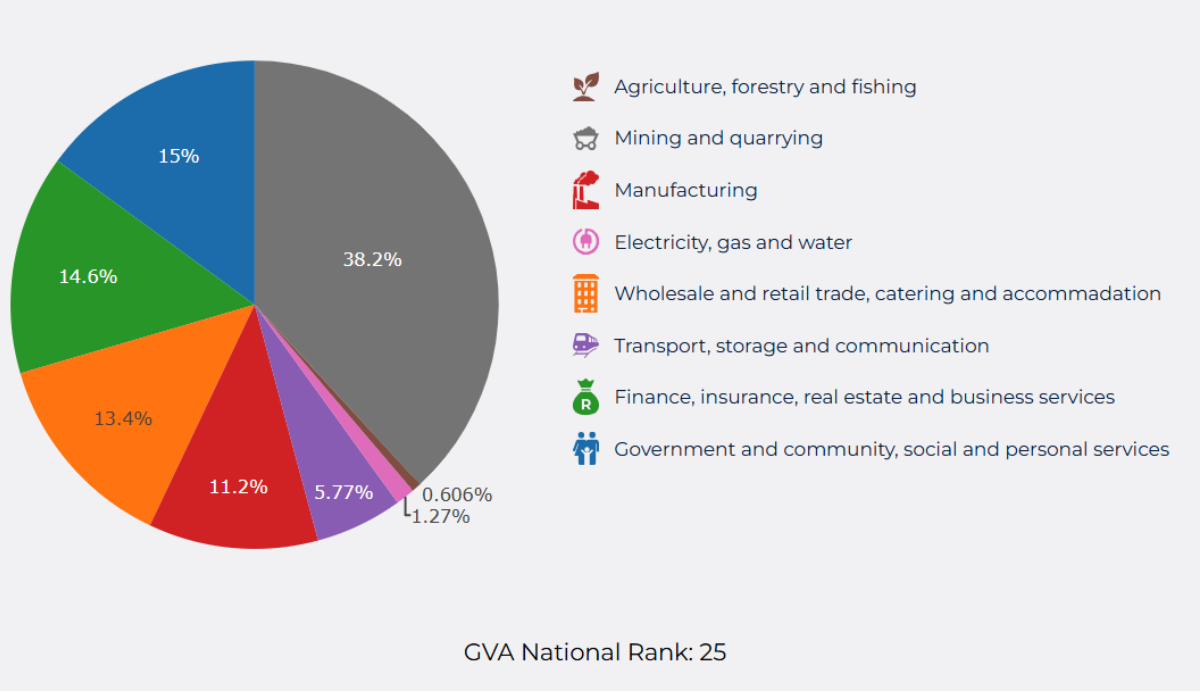


Figure 3-20: The contribution that the different economic sectors make to the total GVA of the Merafong City Local Municipality

Table 3-1 summarises the forecasted economic gains or losses for the Merafong City Local Municipality, under both the RCP4.5 and RCP8.5 scenarios, for each of the contributing economic sectors, with the largest forecasted gains under both RCP scenarios under the Manufacturing sector.

Table 3-1: Forecasted economic gains or losses for the RCP4.5 and RCP8.5 scenarios

RCP 4.5 Impacts			RCP 8.5 Impacts	
Average	0.37% ▲		Average	-0.33% ▼
Agriculture Sector	0.49% ▲		Agriculture Sector	-0.8% ▼
Forestry Sector	0.6% ▲		Forestry Sector	-0.98% ▼
Fishing Sector	0.64% ▲		Fishing Sector	-1.03% ▼
Mining Sector	-0.02% ▼		Mining Sector	0.03% ▲
Manufacturing Sector	0.54% ▲		Manufacturing Sector	1.37% ▲
Electricity & Gas Sector	0.65% ▲		Electricity & Gas Sector	-1.06% ▼
Water Sector	-0.12% ▼		Water Sector	0.2% ▲
Service Sector	0.2% ▲		Service Sector	-0.33% ▼

3.4.5 *Agriculture, Forestry and Fisheries*

The main agricultural commodities for the Merafong City Local Municipality are chickens, maize for grain and pig farming (Table 3-2). Agriculture, Forestry and Fishing (AFF) sector contributes 0.61% to Merafong City Local Municipality GVA production and 2.5% to total employment. The total AFF GVA production of Merafong City Local Municipality contributes 0.13% of the national AFF GVA ranking them as the 167st biggest contributor (Table 3-2).

Table 3-2: Economic contribution of main commodities for Merafong City Local Municipality

ECONOMIC CONTRIBUTION OF MAIN COMMODITIES

MAIN COMMODITIES		
CHICKENS	MAIZE FOR GRAIN	PIGS
CLIMATE IMPACT		
AFF contributes 0.61% to Merafong City GVA production	AFF contributes 2.5% to Merafong City total employment	The total AFF GVA production of Merafong City Municipality contributes 0.13% to the national AFF GVA, ranking them as the 167th biggest contributor

The main agricultural commodities for 2050 for the Merafong City Local Municipality are still chickens, maize for grain and pig farming (under an RCP8.5 low-mitigation scenario) (Table 3-3). For chickens, there will be increased investment requirements to regulate temperature since heat stress poses the biggest risk for this sector towards the end of 2050. For maize for grain, there is a potential increase in maize yield but the heat stress towards 2050 may impact the production negatively. Warm and humid conditions may affect the pig production negatively.

Table 3-3: Projected economic contribution of main commodities for Merafong City Local Municipality

ECONOMIC CONTRIBUTION OF MAIN COMMODITIES

MAIN COMMODITIES		
CHICKENS	MAIZE FOR GRAIN	PIGS
CLIMATE IMPACT		
Change in climate expected: Hotter and wetter with more extreme rainfall events.		
Increased production costs (and increased investment will be required in ventilation and cooling) to maintain optimal seasonal temperatures and reduce the risk of heat stress. Heat stress on birds will reduce body weight gain, reproduction efficiency and egg quality.	Potential increase in maize yield for near future. However, towards 2050, heat stress can negatively impact on production.	Warm and humid conditions negatively affect reproductive efficiency and health.

3.4.6 Other Resources

The impacts of climate change on other resources are summarised in Table 3-4.

Table 3-4: the impacts of climate change on other resources

Parameter	Results of Climate Change				Reference
	Increase in temperature and heat stress	Drought and decrease in rainfall	Increase in rainfall and inland flooding	Increased wind speed	
Transport and Mobility	• Increased rate of infrastructure deterioration leading to pavement failure including cracking, rutting, potholes, flushing, and stripping. • Increased stress on bridges, particularly expansion joints, through thermal expansion and increased movement. • Corrosion of steel reinforcing in concrete structures due to increase in surface salt levels in some locations. • Increased infrastructure maintenance cost for road repair and reconstruction work, causing traffic delays and emergency service response delays. • Increased frequency and intensity of wildfires leading to more road closures. • Increased vehicle accidents, due to low pavement adhesion, leading to higher rates of transport-related fatalities.	• Reduced water resources available for construction and maintenance. • Reduced production of some agricultural produce leading to changes in freight flows in the network.	• Increased rate of infrastructure deterioration, especially in areas with poor infrastructure maintenance history. • Temporary and permanent flooding of road, rail, port and airport infrastructure. • Structural integrity of roads, bridges and tunnels could be compromised by higher soil moisture levels. • Potential destruction of bridges and culverts. • Erosion of embankments and road bases leading to undermining of roads or railways. • Increased risk of landslides, slope failures, road washouts and closures. • Undermining of bridge structures (scouring). • Closure of roadways and tunnels leading to traffic delays. • Transportation system disruptions, impacts to traffic signalling and low water crossings. • Increased weather-related accidents.	• Increased drag on vehicles resulting in increased fuel consumption. • Increased safety risk for pedestrians and cyclists due to flying objects or being uncontrollably dragged by winds, additionally leading to reduced trip making by pedestrians and cyclists.	(Mokonyama & Van Wyk, 2018)
Solid Waste	• Increased risk of combustion at open waste disposal sites and illegal dumps and increase in explosion risk associated with methane gas. • Increased rate of decay of putrescible waste resulting in increased odour, breeding of flies, and attracting of vermin. • Increased health and safety concern regarding heat stroke to staff collecting waste. • Increased risk of landfill site instability and failure due to changes in consumption patterns with increased waste creation (i.e., glass, plastic and paper cups).		• Increased risk of flooding due to pressure on stormwater and leachate management systems at landfills. • Increased demand for capacity to cope with large volumes of waste generated by flood events. • Increase in soil saturation causing decreased stability of slopes and landfills linings (if clay or soil based) at waste management facilities. • Inundation of waste releasing contaminants to waterways, pathways and low elevation zones. • Potential loss of value and degradation of paper and cardboard for recycling due to increased moisture content. • Increased flooding causing the risk of localised disruption of waste collection rounds. • Flooding in areas with untreated, dumped waste causing the risk of groundwater contamination. • Increased flooding causing the risk of litter entering the storm water systems.	• Possible increase in nuisance due to waste dispersed by high winds leading to increased health effects associated with particulate matter (air pollution).	(Oelofse, 2018)

Parameter	Results of Climate Change				Reference
	Increase in temperature and heat stress	Drought and decrease in rainfall	Increase in rainfall and inland flooding	Increased wind speed	
Stormwater	• Potential risk of undermining the temperature regime of temperature-sensitive stormwater ponds and receiving waters, resulting in a decrease in water quality. • Increased corrosion in stormwater drains due to a combination of higher temperatures, increased strengths, longer retention times, and stranding of solids.	• Increased shrinking soils increasing the potential for cracking, increased infiltration and exfiltration of water mains and sewers, which in turn exacerbates treatment and groundwater or storm water contamination.	• Increased risk of flooding due to pressure on stormwater systems. • Increased risk of litter entering the stormwater systems. • Increased risk of damage and failure of stormwater systems due to overloading during floods and intense rainfall events. • Failure of stormwater treatment devices during high flow events leading to by-pass and / or flushing of contaminated water. • High wet-weather hydraulic loads and bottlenecks in stormwater and networks due to inflow and sewer infiltration, leading to local inundation and overflows of untreated wastewater. • Increased rainfall causes soil erosion thus damaging underground stormwater systems. • Increased surface and stream erosion causing deposition of sediments in receiving environments. • Stream morphology for undeveloped, developing and fully developed urban areas, may change, hence affecting existing outfall structures and potential stormwater pond locations.	• Increased wind speed and intensity causing changes in rainfall over complex topography including increasing upwind of hills and ranges.	(Dunker & Van Wyk, 2018)
Sanitation	• Increased heat waves, accompanied by dry weather, can exacerbate already stressed water supply systems leading to competition between sectors for water services, affecting sanitation.	• Decrease in water supply for sanitation through decrease in available water to flush sewage systems adequately. • Declining annual rainfall threatening the viability of water-borne sanitation systems, and the capacity of surface water to dilute, attenuate and remove pollution. • Sewers are structurally vulnerable to drying, hence shrinking soils increase the potential for cracking, increased infiltration, and exfiltration, which in turn exacerbates treatment and groundwater or storm water contamination. • Increased corrosion in sewers due to a combination of higher temperatures, increased strengths, longer retention times, and stranding of solids.	• Increased wet-weather hydraulic loads and bottleneck in stormwater and sanitary sewer networks due to inflow and sewer infiltration, causing local inundation and overflows of untreated wastewater. • Increased rainfall and heavy rainfall events increasing the washing of faecal matter into water sources due to flooding of wastewater treatment works. • Increased risk of flooding resulting in both infrastructure damage and contamination of surface and groundwater supplies. • Increased groundwater levels due to flooding, putting risk on sewage treatment plants (which are often positioned on low-lying ground as sewerage systems rely on gravity). • Increased vulnerability of sewerage pipe systems due to their size and complexity, and their exposure to multiple flood damage threats from source, through treatment, to delivery. • Increased vulnerability of pit toilets (widely used in rural areas) due to flooding, causing serious environmental contamination. • Increase in groundwater recharge and groundwater levels causing flooding of subsurface infrastructure such as pit toilets or septic tanks.		(Duncker, 2018)

Parameter	Results of Climate Change				Reference
	Increase in temperature and heat stress	Drought and decrease in rainfall	Increase in rainfall and inland flooding	Increased wind speed	
Information and Communication Technology	• Increased weathering and deterioration of infrastructure resulting in increased maintenance and repair costs. • Heat stress causing structural damage to infrastructure. • Increased energy demands during heatwaves resulting in power outages which can impact on delivery of telecommunications services. • Increases in temperature and higher frequency, duration, and intensity of heat waves increasing the risk of overheating in data centres, exchanges, and base stations, which can result in increased failure rates of equipment. • Increased mean temperature increasing operating temperature of network equipment which may cause malfunctions if it surpasses design limits.	• Decreased precipitation leading to land subsidence and heave, reducing the stability of telecommunications infrastructure above and below ground (foundations and tower structures).	• Increased risk of flooding of low-lying infrastructure, access holes and underground facilities. • Increases in storm frequency or intensity increasing the risk of damage to aboveground transmission infrastructure and impacting on telecommunications service delivery. • Increases in storm frequency leading to more lightning strikes, consequently damaging transmitters, and overhead cables, causing power outages. • Increased cost of insurance for infrastructure in areas with repeated incidents of flooding, as well as withdrawal of risk coverage in vulnerable areas by private insurers. • Road closures due to flooding thus inhibiting service and/or restoration efforts. • Rising sea levels and corresponding increases in storm surges, increasing the risk of saline corrosion of coastal telecommunications infrastructure, and leading to erosion or inundation of coastal and underground infrastructure.	• Increased risk of storm surges impacting on coastal infrastructure. • Increased storm intensity and frequency impacting on electricity and telecommunications infrastructure.	(Naidoo, 2018)
Health	• More exposure to high temperatures causing increased health risks including heat strokes. • Heat waves increase threat of cardiovascular, kidney, and respiratory disorders. • Increase in fire danger days causing increased loss of life and damage to health infrastructure. • Wildfire smoke significantly reducing air quality, both locally and in areas downwind of fires. Smoke exposure increases respiratory and cardiovascular hospitalizations; emergency department visits; medication dispensations for asthma, bronchitis, chest pain, chronic obstructive pulmonary disease, and respiratory infections; and medical visits for lung illnesses. • Increased emissions in biogenic volatile organic compounds from vegetation causing increases in air pollution. • Increase in evaporative emissions from cars contributing to exposure to, and health impacts from, air pollution. • Increase in distribution of vector-borne diseases in warmer areas. • Increased water temperatures leading to an increase in algal blooms which can likely lead to increases in food- and waterborne exposures. • Increased temperatures combined with fewer clouds (e.g., from increased subsidence that is projected for parts of South Africa) causing increased exposure to Information and Communication Technology which will have negative impacts on health. • Increased temperatures increasing the reaction between certain pollutants and sunlight and heat, resulting in more severe hazardous smog events.	• Decreased soil moisture potentially creating more wind-blown dust which has negative impacts on air quality. • Increase in water-borne diseases and diarrhoeal diseases due to inadequate water availability. • Decreased precipitation causing changes in salinity of water, resulting in an increase in algal blooms which can likely lead to increases in food- and waterborne exposures. • Increase in stagnant air, decreasing air quality.	• Wetter climate combined with increased temperatures may have negative health impacts as many diarrhoeal diseases vary seasonally, typically peaking during the rainy season. • Extreme rainfall and higher temperatures increasing the prevalence of fungi and mould indoors, with increased associated health concerns. • Increased flooding increasing the risk of drinking and wastewater treatment facilities being flooded, meaning that diarrhoeal diseases can be transmitted as wastewater systems overflow or drinking water treatment systems are breached. • Increase in natural disasters (e.g., floods) creating a conducive environment for the occurrence of mental health problems.	• Increase in wind-blown dust combined with low humidity causing increased cases of meningitis (Davis, 2014).	(Garland, 2018)

Parameter	Results of Climate Change				Reference
	Increase in temperature and heat stress	Drought and decrease in rainfall	Increase in rainfall and inland flooding	Increased wind speed	
Energy	• Increased heat causing expansion of overhead cables, and cable sag. Sagging below a certain level result in a reduction in the amount of electricity transmitted. • Increased heat stress on electricity transmission networks (overhead cables). • Increase in heat island effect increasing energy demand for cooling, leading to grid stress. • Increased threat of wildfires causing widespread damage to infrastructure and causing disruptions to service provision.		• Increase in flooding causing damage to electricity transmission and distribution infrastructure, poles, lines and sub-stations. • Increase in frequency and cost of maintenance of concrete structures due to frequent and intense rainfall, flooding, or sea level rise. • Increased repair events increasing stress put on service crews and resulting in delays to power restoration.	• Winds causing damage to energy supply infrastructure as winds cause overhead lines to sag, reducing electricity transmission. • Extreme winds causing poles and trees to fall, causing further damage to energy supply infrastructure such as overhead lines.	(Thambiran & van Wyk, 2018)
Ecosystem Services	• Increased risks of water shortages increasing demand for irrigation of gardens and agriculture. • Increased evapotranspiration rates with rising temperatures, reducing the water available in reservoirs and water available for reliant ecosystems. • Increase in temperature leading to water loss via evapotranspiration resulting in decreased water quality and loss of wetlands. • Loss or degradation of indigenous species, including threatened species or ecosystems. • Increased threat from invasive species as competition for water increases. • Dieback or death of susceptible plants (e.g., street trees) and animals (e.g., fish). • Reduced availability of water and increased evapotranspiration resulting in reductions in harvested area (cropping area), yield (ton/ha) and quality. • Warmer winters resulting in reduced period of dormancy (rest period) in deciduous fruit crops, decreasing the production and quality of associated food products. • Warmer climate resulting in shifts in the growing season and life cycles of various plants, including crops, resulting in pests and diseases having a greater destructive impact as well as a shift in climatically suitable areas for specific crops. • Increased humidity levels resulting in higher rates of microbial growth in fresh produce, reducing their expiry time. • Increased heat stress on crops changes the micro-nutrients of crops products, decreasing the nutrient density and quality of food. • Increased water temperature leading to increased growth of aquatic weeds which increases breeding of disease vectors and reduces water oxygen levels. • Milder winters and reduced frost increase the duration of the growing season, increasing the survival rate of insects and diseases. • Increased sea surface temperatures (SST) causing shifts in the spatial distribution of fish species. • Increased SST and ocean acidification decreases marine phytoplankton growth and synthesis of omega-3 polyunsaturated fatty acids (PUFA's), affecting the oceanic food chain and consequent ecosystems. • Increased heat stress and higher humidity levels	• Decreased amounts of rainfall reaching ecosystems as settlements use rainwater harvesting techniques for increased household use. • Increased reliance on irrigation and greater demand for water to maintain public open space and gardens. • Reduced planting and pollination leading to greater risk of erosion and soil loss. • Increasing temperatures together with increased intensity of drought will potentially increase the occurrence of algal blooms in reservoirs and dams which are damaging to ecosystem functioning and water services. • Drought and decreased rainfall causing wetland habitat loss. • Locally specific changes in humidity levels will have impacts on local vegetation. • Increased threat to watershed and aquifer recharge areas, affecting vegetation. • Reduced soil moisture availability increasing moisture stress leading to dieback and death of plants and the loss or degradation of indigenous communities, including threatened species or ecosystems. • Increased moisture stress leading to decline in crop yield and quality, and reduced fodder quantity and quality for livestock. • Drying up of aquatic systems, perennial systems will become seasonal and seasonal systems will die off and be replaced by terrestrial plants. • Increased spread of drought-adapted alien invasive plant species.	• Rainfall in shorter and more violent spells making recharging groundwater difficult. • Increase in intensity of rainfall and flooding leading to increased surface runoff, resulting in increased soil erosion, soil loss and degradation. • Increased rainfall and floods resulting in waterlogged soils which increase the likelihood of crop failure. • Increasingly saturated soils leading to more standing water (ponding) which can result in more insect (pest) activity and their potential to carry diseases. • Increased wave energy and run-up (sea level rise and more storms) causing degradation of natural coastal defence structures.	• Evapotranspiration rates increase with wind speed, reducing the water available in reservoirs and water available for reliant ecosystems. • Increased rate of fire spread and spotting (the ignition of fires ahead of the main fire front) of fires. • Potential damage to or uprooting of vegetation including trees, which can also damage infrastructure. • Potential wind damage to crops, reducing yield and quality (e.g., sandblasting and fruit fall). • Increased windblown materials (e.g., dust, litter) increasing the need for maintenance and city cleaning. • Degradation of natural coastal defence structures and increased damage to hard coastal infrastructure.	(Pieterse & Crankshaw, 2018)

Parameter	Results of Climate Change				Reference
	Increase in temperature and heat stress	Drought and decrease in rainfall	Increase in rainfall and inland flooding	Increased wind speed	
	potentially resulting in the exceedance of the temperature humidity index in livestock, causing reduced immunity, fertility, productivity and even mortality of livestock.				
Culture and Heritage	• Increased temperature having significant impacts on the comfort levels of built heritage resources, resulting in the building no longer being fit-for-purpose. • Increased demand for additional heating and cooling resulting in the installation of heating, ventilation, and air-conditioning systems with potential negative consequences on the heritage value. • Increased heat stress potentially impacting on the materials and structural integrity of heritage resources. • Migration of several plant species due to changing climate patterns, posing a threat to the conservation of biodiversity hotspots, and potentially altering heritage places. • Increase in veld and forest fires raising the threat of fire to all heritage resources, natural and built, as well as posing health risks to heritage resource dwellers from exposure to smoke and ash pollution.	• Decreased rainfall impacting negatively on ground moisture levels and thus the geological conditions of sensitive heritage resources. Drying out clays, for example, will shrink and potentially undermine founding conditions.	• Increased rainfall in areas with clay soils resulting in swelling which poses a threat to the structural integrity of heritage resources. • Increased floods and changes in precipitation resulting in increasing vulnerability of archaeological evidence buried underground due to changing stratigraphic integrity of the soils. • Increased threat to materials and structural integrity of heritage resources exposed to higher humidity/ precipitation levels.		(van Wyk, 2018)

4 GHG INVENTORY

4.1 Approach and Methodology

This assessment has been undertaken in accordance with the principles of:

- ISO 14064-1:2006 Greenhouse gases – Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals.
- Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (GHG Protocol) (World Business Council for Sustainable Development and World Resources Institute, 2015).
- IPCC Fifth Assessment Report (2014).

These guidelines are considered representative of good practice GHG accounting internationally and are applicable to the project.

The Greenhouse Gas Protocol Corporate Accounting and Reporting Standard (WRI & WBCSD, 2004), provides two approaches. This includes the assessment of GHGs based on: (1) the organisational boundaries and (2) operational boundaries. For the calculation of GHG footprint for the project, the operational boundary approach was selected.

4.1.1 Organisational Boundaries

For corporate reporting, two distinct approaches can be used to consolidate GHG emissions: the equity share and the control approaches. Companies shall account for, and report, their consolidated GHG data according to either the equity share or control approach as presented below.

In setting organizational boundaries, a company selects an approach for consolidating GHG emissions and then consistently applies the selected approach to define those businesses and operations that constitute the company for the purpose of accounting and reporting GHG emissions. If the reporting company wholly owns all its operations, its organizational boundary will be the same whichever approach is used. For companies with joint operations, the organizational boundary and the resulting emissions may differ depending on the approach used. In both wholly owned and joint operations, the choice of approach may change how emissions are categorized when operational boundaries are set.

4.1.2 Operational Boundaries

To help delineate direct and indirect emission sources, improve transparency, and provide utility for different types of organizations and different types of climate policies and business goals, three “scopes” (scope 1, scope 2, and scope 3) are defined for GHG accounting and reporting purposes (Figure 4-1).

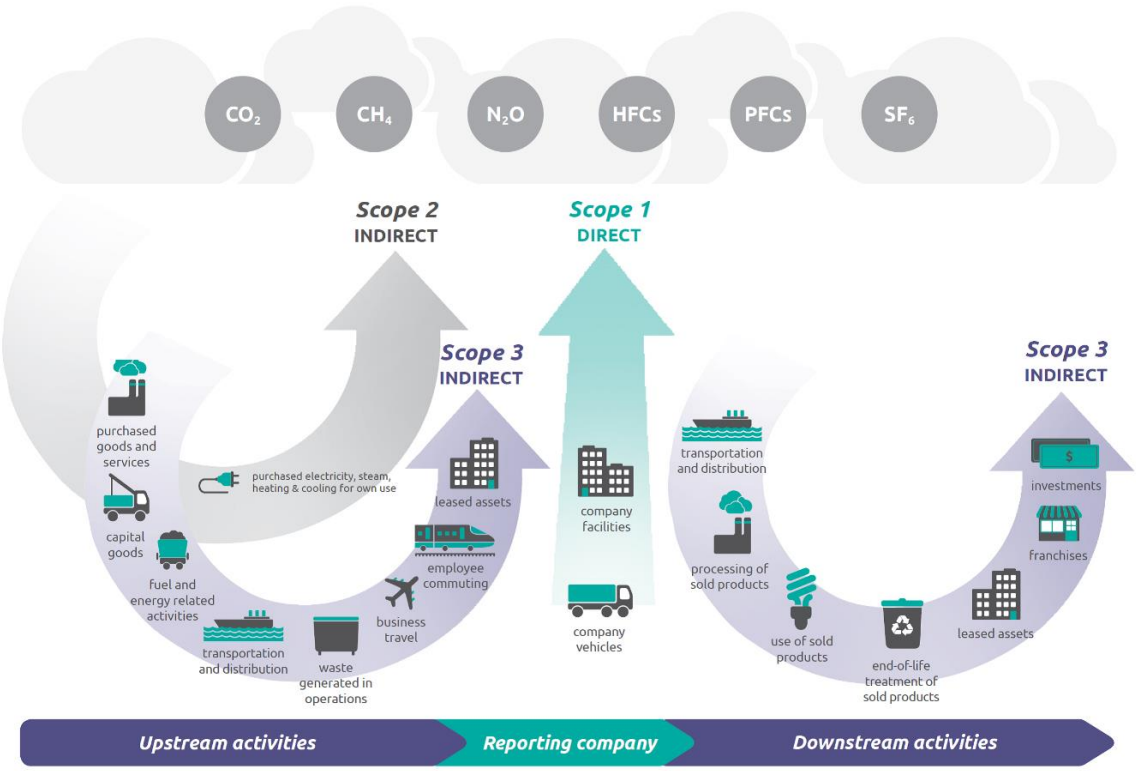


Figure 4-1: Overview of scopes and emissions (WRI & WBCSD, 2004)

4.1.2.1 Scope 1: Direct GHG Emissions

Direct GHG emissions occur from sources that are owned or controlled by the company, for example, emissions from combustion in owned or controlled vehicles, etc.; and/or emissions from gold production in owned or controlled process equipment.

4.1.2.2 Scope 2: Electricity - Indirect GHG Emissions

Scope 2 accounts for GHG emissions from the generation of purchased electricity consumed by the company. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organizational boundary of the company. Scope 2 emissions physically occur at the facility where electricity is generated.

4.1.2.3 Scope 3: Other Indirect GHG Emissions

Scope 3 is an optional reporting category that allows for the treatment of all other indirect emissions. Scope 3 emissions are a consequence of the activities of the company but occur from sources not owned or controlled by the company. Some examples of scope 3 activities are extraction and production of purchased materials; transportation of purchased materials and product; and use of sold products.

4.2 Greenhouse Gases and Global Warming Potential

The GHGs considered in this assessment and the corresponding global warming potential (GWP) for each GHG are listed in Table 4-1. GWP is a metric used to quantify and communicate the relative contributions of different substances to climate change over a given time horizon. GWP accounts for the radiative efficiencies of various gases and their lifetimes in the atmosphere, allowing for the impacts of individual gases on global climate change to be compared relative to those for the reference gas carbon dioxide. This study follows the approach stipulated in National GHG reporting guidelines (DFFE, 2022) as reported in Section 2.5.1.

4.3 Assessment Boundary

The following GHG emissions have been considered:

- Scope 1 process emissions: Current operations and Proposed Future operations (no Scope 1 emissions from Construction Phase);
- Scope 2 energy consumption: Current operations and Proposed Future operations (no Scope 2 emissions from Construction Phase); and,
- Scope 3 external activities: Current operations, Construction Phase and Proposed Future operations.

4.4 Greenhouse Gas Emissions

The emission factors used for the assessment are provided in Appendix C and were sourced from the:

- South African Methodological Guidelines for Quantification of Greenhouse Gas Emissions *gazetted by the* Department of Forestry, Fisheries and Environment, No. 47257(2598) (DFFE, 2022b).
- South Africa's 2022 Grid Emission Factors Report *gazetted by the* Department of Forestry, Fisheries and Environment, No. 51495(5498).
- The United Kingdom Department for Energy Security and Net Zero Greenhouse gas reporting: conversion factors 2026 (DEFRA, 2026).

4.4.1 Current Operations

The Kusasalethu processing plant is currently under care and maintenance. Production has ceased and the majority of employees have been redeployed to other operations. Only the process water circuit and backfill system remain operational to supply adjacent underground workings. Activities are limited to asset preservation, statutory inspections, security, housekeeping, preventative maintenance and operation of essential services. Major maintenance is deferred unless required for safety or reliability. Mobile cranes are hired only when required. Maintenance spares are procured from local suppliers in Carletonville and specialist suppliers in Johannesburg.

Information provided was based on the following assumptions:

- Electrical demand remains at approximately 3 MVA connected load with 0.8 average power factor operating continuously for water and backfill systems (21.024 GWh/year).
- Three security patrol vehicles operate continuously (24 h/day) averaging 150 km/day each.

- One diesel forklift operates 2 h/day.
- One plant Light Duty Vehicle (LDV) operates 80 km/day.
- Hired crane assumed 12 visits/year from Johannesburg (200 km return).
- Maintenance spares: 70% sourced from Johannesburg, 30% locally from Carletonville.
- Maintenance workforce: engineer, multiskilled foreman, fitter, two assistants, shared electrician, instrument technician, rigger and forklift operator (day shift).
- Operations: four foremen, four operators and four assistants across rotating shifts.
- Security staffing: six on-site plus six off shift internally, four gate personnel (two on duty/two off) with three patrol vehicles.

A summary of the current operations with the estimated GHG emissions are provided in Table 4-1. The raw data with associated assumptions are provided in Appendix D.

Table 4-1: Deelkraal II Current Operations – Source data and calculated GHG emissions

Categories	Description/ Equipment	Value	Unit	Emissions (tCO_2e)
Scope 1 Direct				
Mobile combustion - diesel	Crane	1.6	TJ/year	133.07
Mobile combustion - petrol	Forklift	0.1	TJ/year	7.04
Scope 2 Indirect				
Electricity use	Eskom – National Grid factor	21 024	MWhr	19 573
Scope 3 Indirect				
Purchased goods & services	water consumption	876	m^3/year	0.17
Upstream transportation	total km for a range of trucks & equipment	28 000	km/year	23.69
Waste generated	industrial waste	20.2	tonnes/year	10.52
	office waste	3	tonnes/year	1.49
	lubricant oil	1.5	tonnes/year	0.01
Business travel	Double cab - diesel	20 000	km/year	3.96
	rental Sedans - petrol	5 000	km/year	0.87
Employee commuting	minibus taxi – 24 people	187 200	km/year	807.90
	car - 10 people	78 000	km/year	135.81
	motorcycle - 2 people	15 600	km/year	3.55

4.4.2 Construction Phase Operations

The Construction phase will include the construction of the proposed Deelkraal II TSF as well as the upgrading of the Kusaselethu Gold Plant. Additional planned infrastructure includes slurry, potable, sewage and return water pipelines, access roads, pump stations, a return water dam and a power line (see Section 1.1).

Information provided was based on estimates and assumptions as summarised below. Construction operations will be done by Contractors, with Current operations as reported under Section 4.4.1 continuing as usual. Thus, all emissions for the Construction Phase fall under Scope 3.

Deelkraal II TSF Construction:

- Construction duration: 30 months (2.5 years) - 260 operating days per year with six-day working weeks.
- Peak double-shift operations during starter wall construction.
- Average haul distance of 10 km one-way (20 km return).
- Diesel used for heavy equipment; petrol used for light vehicles and small equipment.
- Routine servicing every 250–500 operating hours.
- TSF earthworks including starter walls, drains, culverts, RWDs, roads and diversion channels[15].
- Mechanical, electrical and instrumentation equipment supplied from Johannesburg (approximately 90 km one-way).
- Waste rock and G5 sourced from local quarries/borrow pits approximately 10 km from site.
- Concrete supplied from a local batching plant within approximately 40 km.
- Diesel, petrol and lubricants sourced from local Carletonville fuel distributors, with an assumed average delivery distance of 10 km one-way.
- All transport undertaken using diesel-powered heavy commercial vehicles.
- Maximum workforce: 500 people
- Average commute: 15 km one-way
- Shared transport utilised by approximately 85% of the workforce
- Annual vehicle distance: 507 000 km
- Annual fuel consumption: 38 990 L diesel and 15 600 L petrol

Kusasalethu Gold Plant upgrade:

- Construction duration: 30 months (2.5 years).
- Peak workforce: Plant 292 personnel; Pump Station & Overland 214 personnel.
- Average EPCM site staff: 18 people/day.
- Average supplier representatives: 6 people/day.
- 260 working days per year.
- Plant receives permanent power and water early during construction; temporary generators are therefore limited.
- Pump Station and Overland require temporary diesel generators until permanent electrical infrastructure is commissioned.
- Diesel includes contractor-owned construction equipment and temporary generators.
- Petrol includes EPCM, owner and supplier light vehicles.
- Business Travel: approximately 173,000 vehicle-km/year by road and 45,200 passenger-km/year by air.
- Employee Commuting: approximately 622,500 vehicle-km/year based on a peak workforce of 500 personnel.

[15] Clearance loss of above ground carbon stocks for the TSF was not considered since the area was assumed to be disturbed land.

A summary of the Construction Phase operations with the estimated GHG emissions are provided in Table 4-2 for the TSF Construction and in Table 4-3 for the processing plant upgrade. The raw data with associated assumptions are provided in Appendix C.

Table 4-2: Deelkraal II TSF Construction Operations – Source data and calculated GHG emissions

Categories	Description/ Equipment	Value	Unit	Emissions (tCO_2e)
Scope 1 Direct				
Assumed to remain the same as Current Operations		-	TJ/year	-
Scope 2 Indirect				
Assumed to remain the same as Current Operations		-	MWhr	-
Scope 3 Indirect				
Purchased goods & services	water consumption	14 600	m^3/year	2.79
	materials (waste rock, G5, burrow pit, crusher rock)	2 000 000	tonnes/year	15 606.14
	concrete	1 895	tonnes/year	225.13
	steel/metal	471	tonnes/year	1 798.61
Capital goods/ assets (incoming)	equipment purchased	71	tonnes/year	231.96
	materials purchased	7.3	tonnes/year	0.55
Fuel- and Energy related activities not included in Scope 1 & 2	petrol	54 800	litres/year	31.84
	diesel	3 040 000	litres/year	1 857.47
	lubricants	9.6	tonnes/year	10.72
Upstream transportation	total km for a range of trucks & equipment	475 720	km/year	402.49
Waste generated	industrial waste	5.5	tonnes/year	2.86
	office waste	2.1	tonnes/year	1.04
	hazardous waste	25.1	tonnes/year	0.12
Employee commuting	contractor busses – 50 people	985 500	passenger.km/ year	123.70
	minibus taxi – 15 people	6 570 000	passenger.km/ year	1 181.42
	car – 2 people	13 797 000	passenger.km/ year	2 402.20

Table 4-3: Kusaselethu Gold Plant Construction Operations – Source data and calculated GHG emissions

Categories	Description/ Equipment	Value	Unit	Emissions (tCO_2e)
Scope 1 Direct				
Assumed to remain the same as Current Operations		-	TJ/year	-
Scope 2 Indirect				
Assumed to remain the same as Current Operations		-	MWhr	-
Scope 3 Indirect				
Purchased goods & services	water consumption	15 148	m³/year	2.90
	materials (waste rock, G5, burrow pit, crusher rock)	130 600	tonnes/year	1 019.08
	concrete	13 100	tonnes/year	1 556.32
	steel/metal	1 535	tonnes/year	5 866.69
Capital goods/ assets (incoming)	equipment purchased	3543	tonnes/year	11 574.98
	materials purchased	0	tonnes/year	0.00
Fuel- and Energy related activities not included in Scope 1 & 2	petrol	71 000	litres/year	41.25
	diesel	492 000	litres/year	300.62
	lubricants	4.3	tonnes/year	4.80
	LPG	1 200	kg/year	0.42
	Welding gas	3	tonnes/year	0.01
Upstream transportation	total km for a range of trucks & equipment	100 450	km/year	84.99
Waste generated	industrial waste	366.4	tonnes/year	476.85
	office waste	50	tonnes/year	62.16
	hazardous waste	14	tonnes/year	0.16
	lubricant oil	6	tonnes/year	0.07
Business travel	rental Sedans - petrol	16 000	km/year	2.79
	domestic flights (economy) – 12	6 457	passenger-km/year	1.48
	international flights (economy) - 2	38 743	passenger-km/year	4.23
Employee commuting	contractor busses – 50 people	37 500	passenger.km/ year	4.71
	minibus taxi – 15 people	112 500	passenger.km/ year	303.45
	car – 2 people	472 500	passenger.km/ year	164.53

4.4.3 Proposed Future Operational Phase

In future the new Deelkraal II TSF will receive residue from Kusasalethu- and Savuka gold plants and assist in returning process water for reclaiming the existing Deelkraal I TSF and Kusasalethu TSF for processing at Kusasalethu plant.

Information provided was based on the following assumptions:

- Plant throughput: 6.6 Mt/year operating approximately 8 000 hours/year.
- Continuous operation of slurry pumps, agitators, carbon regeneration kiln, elution plant, compressors and utilities.
- Routine preventive maintenance in accordance with OEM schedules.
- Lubricant consumption includes oil changes, top-up oil and grease used during normal maintenance.
- Purchased lubricant mass = 3.5 t/year.
- Packaging mass assumed at 5% of lubricant mass = 0.18 t/year.
- Upstream transport assumes suppliers located in Johannesburg with an average one-way distance of 90 km to site.
- Freight activity = 3.5 t × 90 km = 315 tonne-km/year.
- Four dedicated deliveries per year equate to approximately 720 vehicle-km/year if not consolidated with other maintenance deliveries.
- Used lubricant recovery assumed at 80% of purchases: 3.5 × 80% = 2.8 t/year.

A summary of the future Operational Phase operations with the estimated GHG emissions are provided in Table 4-4. The raw data with associated assumptions are provided in Appendix C.

Table 4-4: Proposed Deelkraal II TSF and Kusaselethu Gold Plant Operations – Source data and calculated GHG emissions

Categories	Description/ Equipment	Value	Unit	Emissions (tCO_2e)
Scope 1 Direct				
Stationary Combustion - diesel		40.9	TJ/year	3 062.48
Stationary Combustion - LPG		100.1	TJ/year	6 320.72
Mobile combustion - diesel	Crane	1.846	TJ/year	153.59
Mobile combustion - petrol	Forklift	0.1	TJ/year	9.65
Mobile combustion - lubricants		0.15	TJ/year	10.79
Scope 2 Indirect				
Electricity use	Eskom	174 380.8	MWhr	162 348.52
Scope 3 Indirect				
Purchased goods & services	water consumption	240 900	m^3/year	46.08
	reagents needed for operation:		tonnes/year	0.00
	- Lime	11 379	tonnes/year	8.53
	- Cyanide active NaCN	2 640	tonnes/year	9.24
	- Oxygen	6 300	tonnes/year	1.26
	- Caustic 48%	3 053	tonnes/year	3.66
	- HCl 33%	622	tonnes/year	0.56
	- Carbon	396	tonnes/year	3.96
	- Flocculants	37.5	tonnes/year	0.15
Capital goods/ assets (incoming)	equipment purchased	430	tonnes/year	1 404.81
	materials purchased	700	tonnes/year	52.50
Fuel- and Energy related activities not included in Scope 1 & 2	petrol	4 000	litres/year	2.32
	diesel	304 000	litres/year	185.75
	LPG	1 200	kg/year	419.15
	lubricants	3.7	tonnes/year	4.08
Upstream transportation	total km for a range of trucks & equipment	7 300 000	tonne.km/year	6 176.24
Waste generated	industrial waste	212	tonnes/year	110.36
	office waste	66	tonnes/year	32.82
	lubricant oil	7.5	tonnes/year	0.03
	hazardous waste	28	tonnes/year	0.13
Business travel	rental Sedans - petrol	16 000	km/year	2.79
Employee commuting	contractor busses – 50 people	250 125	passenger.km/year	31.40
	minibus taxi – 15 people	450 225	passenger.km/year	1 214.39
	car – 2 people	100 050	passenger.km/year	34.84
Downstream transportation	Air (helicopter)	0.2	tonnes/year	3.46
		8 640	km/year	
Use of sold products	Jewellery, electrical components, etc.	56.7	oz/annum	0.01

4.5 Emissions Summary

The estimated GHG emissions due to project operations is provided in Table 4-5 for the Current Operations, Construction Phase and the future Project operations.

Table 4-5: Estimated GHG emissions for the operational phase of the project

	Annual Emissions (tCO_2e)			
	Current Operations	Construction Operations [a]		Future Operations
		Deelkraal II TSF	Kusaselethu Gold plant	
Scope 1 - Stationary and mobile combustion	140	-	-	9 557
Scope 2 - Electricity use	19 573	-	-	162 349
Scope 3 - All	988	23 879	21 149	9 749
Total Emissions	**20 701**	**45 028**		**181 654**

Notes: [a] emissions were calculated for the entire construction period of 2.5 years but reported as GHG emissions per annum.

Scope 1 emissions will be highest during the proposed operations at 9 557 tCO_2e per annum. Similarly, Scope 2 emissions will be highest during the future operations at 162 349 tCO_2e per annum. Scope 3 emissions will be highest during construction at 45 028 tCO_2e per annum – this is due to the use of purchased goods and services as well as incoming capital goods during construction of the TSF and Plant.

For comparison, international reporting considers a small facility as producing 10 000 tCO_2e per annum, medium at 25 000 tCO_2e per annum and large at 100 000 tCO_2e per annum (for Scope 1 and 2 emissions). This project, once operational, would thus be considered a large facility mainly due to its Scope 2 emissions.

4.6 The Project's GHG Impact

4.6.1 Impact on the National Remaining Carbon Budget, the National Inventory and the Project Inventory

According to the updated second NDC (Section 2.3), the South African remaining carbon budget is in the range of 320 – 380 Mt CO_2e by 2035. Using the lower end of the range for 2035, the project activities (Scope 1 and Scope 2) would contribute approximately 0.054% of the remaining carbon budget per year represent a contribution of 0.04% (Project) to the 2022 National GHG inventory total (including LULUCF).

4.6.2 Alignment with National Policy

Most of the South African GHG policy is in early phases of implementation where GHG emissions have been reported to DFFE since 31 March 2018 and the Carbon Tax Act came into effect on the 23 May 2019. The project will be required to align GHG reporting with national policy. An annual Carbon Tax environmental levy account will need to be submitted in July of each year after operations commence.

4.7 Physical Risks of Climate Change to the Project's Operations

With the increase in temperature, there is the likelihood of an increase in discomfort and possibility of heat related illness (such as heat exhaustion, heat cramps, and heat stroke). Both these have the potential to negatively affect employee performance and productivity along with process efficiency.

From a process point of view, elevated ambient temperatures (up to 45°C) may slightly increase evaporative fuel losses from vehicles and increase temperature related wear on equipment. Similarly, there will be increased water use for drinking water and operational dust emission abatement requirements.

The projected increase in rainfall should be considered in the TSF design which may pose a risk to the structural stability in future.

4.8 Transitional Risks and Opportunities of Climate Change on the Project's Operations

The Taskforce for Climate-related Financial Disclosures (TCFD) advocates the disclosure of the financial risks associated with climate change impacts on organisations (TCFD, 2020). These include physical risks resulting in large-scale financial losses caused by storms, droughts, wildfires, and other extreme events (as identified in Section 3). The Taskforce also advocates the quantification of transitional risks associated with the adjustment to low carbon economies, such as the rapid loss in the value of assets due to policy changes or consumer preference; and financial risks to the economy through elevated credit spreads, greater precautionary saving and rapid pricing readjustment (TCFD, 2020). Along with risks, the Taskforce encourages organisations to identify possible opportunities that could build resilience in economies shifting due to climate change.

Although the full financial risk is out of the scope of the of work, potential transitional risks and opportunities applicable to the project are tabulated below (Table 4-6 as summarised from TCFD, 2017).

Table 4-6: Examples of climate-related risks and opportunities and the potential financial impacts (TCFD, 2017)

Type	Climate Related Risk / Opportunity	Potential financial impact	Comments
Risks	Policy and Legal		
	- Increased pricing of GHG emissions	- Increased operating costs (for example higher compliance cost, increased insurance premiums)	Carbon tax act proposed 2% increase in baseline carbon tax rate until 2022 and, thereafter, annual inflation-based increases
	- Enhanced emissions reporting obligations	- Write-offs, asset impairment, and early retirement of existing assets due to policy changes	SAGERS online GHG emissions reporting platform since 2020
	- Mandates on and regulation of existing products and services	- Increased costs and / or reduced demand for products and services resulting from fines and judgements.	Country commitment to decarbonise energy supplies by 2050 could influence energy demand. Exceedances of emission standards could result in fines and litigation.
	- Exposure to litigation		
	Technology		
	- Substitution of existing products and services with lower emission options	- Write-offs and early retirement of existing assets	Country commitment to decarbonise energy supplies by 2050 could influence product demand.
		- Reduced demand for products and services	
	- Costs to transition to lower emissions technology	- Capital investments in technology development	
		- Costs to adopt / deploy new practises and processes	
	Market		
	- Changing customer behaviour	- Reduced demand for goods and services due to shift in consumer preferences	
	- Increased cost of raw materials	- Increased production costs due to changing input prices (for example, energy).	Increased energy cost through demand and availability drivers.
		- Abrupt and unexpected shifts in energy costs	
	Reputation		
	- Shifts in consumer preferences	- Reduced revenue from decreased demand for goods and services	Country commitment to decarbonise energy supplies by 2050 could influence product demand.
		- Reduced revenue from decreased production capacity (delayed planning approvals, supply chain interruptions)	

Type	Climate Related Risk / Opportunity	Potential financial impact	Comments
	- Increased stakeholder concern or negative stakeholder feedback	- Reduction in capital availability	
Opportunities	Resource efficiency		
	- Use of more efficient modes of transport	- Reduced operating costs (through efficient gains and cost reductions)	
	- Use of more efficient production and distribution processes	- Increased production capacity, resulting in increased revenue	
	- Use of recycling	- Capital costs of alternative water supplies	Investigation of alternative water supplies could open opportunities to recycle or reuse water since water supplies may become constrained by quality.
	Energy source		
	- Use of lower-emission sources of energy	- Reduced operational costs - Reduced exposure to GHG emissions and therefore less sensitive to changes in cost of carbon - Increased capital availability (e.g. as more investors favour lower-emission producers) - Reputational benefits resulting in increased demand for goods/services	
	- Shift towards decentralized energy generation	- Reduce exposure to fossil fuel price increases	
	- Participation in carbon market		Carbon tax incentives (through sequestration allowances)
	Products and services		
	- Shifts in consumer preferences	- Better Competitive position to reflect shifting consumer preferences, resulting in increased revenues	
	Markets		
	- Access to new markets	- Increased revenue through access to new and emerging markets (for example partnerships with governments, development banks)	
	- Use of public-sector incentives		

4.9 Project Adaptation and Mitigation Measures

Climate change management includes both mitigation and adaptation. The main aim of mitigation is to stabilise or reduce GHG concentrations as a result of anthropogenic activities. This is achievable by lessening sources (emissions) and/or enhancing sinks through human intervention. Mitigation measures are typically the focus of the energy, transport and industry sectors (Thambiran & Naidoo, 2017). Adaptation measures focus on the minimising the impact of climate change, especially on vulnerable communities and sectors. Inclusion of the climate change adaptation in business strategic implementation plans is one of the outcomes defined in the Draft National Climate Change Adaptation Strategy (Government Gazette No.42466:644, May 2019).

4.9.1 General Adaptation

Additional support infrastructure can reduce the climate change impact on the staff and project, for example the improving thermal and electrical efficiency of buildings to reduce electricity consumption, ensuring adequate water supply for staff, amending summer operating hours to avoid the hottest part of the day and potential health and safety impacts for employees.

Contingencies for very hot days and extreme rainfall days should be built into emergency response plans and EMP for the mine.

A community development program could be initiated to assist communities near the plant that are vulnerable to climate change impacts, such as thermal and electrically efficient buildings (to minimise electricity needs for heating and cooling) and energy efficient stoves (to minimise the use of woody biomass harvested from natural forests).

4.9.2 (Technology/Sector-Specific) Mitigation

The industry should explore and adopt best available technologies to improve energy efficiency and reduce CO_2 emissions from production processes. In addition, the wheeling of electricity could be investigated using renewable energy to offset a portion of the grid feed requirements for the project.

Carbon offset options could also include investment in REDD+ (Reducing Emissions from Deforestation and forest Degradation) initiatives (Thambiran & Naidoo, 2017). REDD+ initiatives in developing countries incentivise communities to undertake forestry and related activities that can contribute to reducing land based GHG emissions associated with deforestation and degradation and through sequestration of CO_2 in forests and agroforestry (Thambiran & Naidoo, 2017). REDD+ programmes are also mechanisms for socio-economic development. However, the expansion of the forestry industry in South Africa, will require quantification of the impact of expanded activities on water resources (as highlighted in the Draft National Climate Change Adaptation Strategy (Government Gazette No.42466:644, May 2019).

Since the area is grassland and alternative to consider is that the degraded land can be used for renewables instead of covering virgin land with acres of PV arrays The clean energy transition needs land. Can it help restore it too? | UN News.

5 IMPACT SIGNIFICANCE RATING

5.1 Potential Impact Description

Gaseous pollutants released from the combustion of fuel is the main source of direct GHGs from the project while indirect emissions from imported electricity is the largest source overall. The release of GHG includes mainly CO_2, CH_4 and N_2O. GHGs are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapour H_2O, CO_2, N_2O, CH_4 and O_3 are the primary GHG in the Earth's atmosphere. The effect of climate change is related to changing atmospheric GHG concentrations, increased temperatures, changing weather patterns and sea level rise (indirect negative impact).

5.2 Impact Significance

The calculated annual CO_2e emissions from the project construction operations for Scope 1, and 3 is summarised in Section 4.5, estimating 172 935 t when accounting for the current operations plus the construction operations.

The project Scope 1 and Scope 2 emissions due to the project (future operations only) would contribute approximately 0.054% of the remaining carbon budget per year for 2035 and represent a contribution of 0.04% to the 2022 National GHG inventory total (including LULUCF).

Local reporting requirements have yet to be developed to describe and assess environmental impacts for GHGs. Guidance is thus taken from international guidelines such as that developed for the Sacramento Metropolitan Air Quality Management District (SMAQMD, 2014). As part of the process to determine if a full GHG analysis and mitigate programme is required, an Initial Study is implemented to determine if a project may have a significant effect on the environment. As such a threshold of 1 100 tCO_2e (project construction phase) and 10 000 tCO_2e (operational phase) for stationary source projects per year is applied to new projects (SMAQMD, 2014). These thresholds were based on capturing 90% of the development projects across the state, ensuring that small projects, which generally have low emission levels, and would generally not be considered significant. As an alternative method of measure, a GHG threshold may be based on the classification of projects by the European Bank for Reconstruction and Development (EBRD), in which projects contributing more than 25 000 tCO_2e per year to have significant GHG emissions (EBRD 2019). This is in line with the International Finance Corporation (IFC 2012). Section 8 of the IFC Performance Standards on Environmental and Social Sustainability: "For projects that are expected to or currently produce more than 25 000 t CO_2e annually the client will quantify direct emissions from the facilities owned or controlled within the physical project boundary, as well as indirect emissions associated with the off-site production of energy used by the project. Quantification of GHG emissions will be conducted by the client annually in accordance with internationally recognised methodologies and good practice". In terms of the Equator Principles, a developer that is seeking funding from a financial institution that subscribes to the Equator Principles is required to publicly report on its combined Scope 1 and Scope 2 GHG emissions if it exceeds 100 000 tCO_2e annually, for the operational phase of the project, during the life of the loan (Equator Principles, 2013). The Equator Principles also encourage clients to report publicly on projects emitting over 25 000 tCO_2e, in line with the IFC Performance Standards (Equator Principles, 2013). As a further example, the South African Declaration of Greenhouse Gases as Priority Pollutants (GG 40966 of 21 July 2017) define production processes

in Annexure A of the Declaration with the requirement to submit a Pollution Prevention Plan (PPP) (referred to as greenhouse gas mitigation plans in the Climate Change Act gazetted on 23 July 2024) to the Minister for approval with GHG in excess of 100 000 tCO_2e.

When evaluating significance, all new GHG emissions contribute to a negative environmental impact; however, some projects could replace existing development or baseline activity that has a higher GHG profile. Therefore, the significance of a project's emissions should be based on its net impact over its lifetime, which may be positive, negative or negligible. To meet the South African (SA) NDC targets and interim budgets, action is required to reduce GHG emissions from all sectors, including projects in the built and natural environment. The proposed project must therefore consider whether and how the project will contribute to or jeopardise the achievement of these targets. Such an assessment would however require a much broader evaluation of the project against all current energy mix and their resources practiced in South Africa. In the absence of such a comprehensive assessment, the current assessment will rely on using thresholds to define the significance of the GHG impact. The elements to consider are listed in table 5-1.

Table 5-1: GHG and Climate in EIA – Elements to consider

GHG emissions (tonnes CO_2e/year)	Qualitative rating	Elements of assessment to consider
GHGs < 25 000	Very Low	Quantify GHG
25 000 < GHGs < 100 000	Low	Look at possible mitigation, quantify GHG, place in context
100 000 < GHGs < 1 000 000	Medium	As above and prepare management plan, describe existing climate conditions, consider how changes in climate may affect project and surroundings
GHGs > 1 000 000	High	As above and consider adaptation analyses

The GHG emissions for the construction phase, considering the current operations would continue throughout construction operations, are 19 713 tCO_2e for Scope 1 and Scope 2 and considered **Very Low**.

The GHG emissions for future project operations (171 906 tCO_2e) per annum for Scope 1 and Scope 2 are 0.054% of the total gross SA GHG emissions. The impact significance is therefore considered to be **Medium**.

6 FINDINGS

Project specific information together with local and internationally published emission factors were used to calculate Scope 1 (direct), Scope 2 (indirect) and Scope 3 (indirect) GHG emissions for the proposed project. Locally published literature was referred to, to understand the projected changes to climate for the area.

Based on information provided, the project is likely to result in an estimated total of 9 557 t CO_2e per annum direct emissions (Scope 1) and 162 349 t CO_2e per annum indirect emissions (Scope 2) due to operational activities, with 9 749 t CO_2e per annum indirect (Scope 3) emissions. The GHG emissions from the project for the operation was calculated to represent 0.054% of the remaining South African annual budget for 2035.

The impact of the project on climate change was assessed to have a **Medium** negative risk rating.

The project will be required to report CO_2e emissions annually via the NAEIS.

7 REFERENCES

Cole, M., Bailey, R., Cullis, J., & New, M. (2017). Spatial inequality in water access and water use in South Africa. *Water Policy*, 20 (1): 37–52.

CSIR. (2019). Retrieved from Green Book: Adapting South African settlements to climate change.: www.greenbook.co.za

Davis, C. E. (2014). *The International Traveler's Guide to Avoiding Infections. Myers, J., Young, T., Galloway, M., Manyike, P. and Tucker, T. 2011 'References esponding to climate change in southern Africa – the role of research',.*

DEFRA. (2026). *Greenhouse gas reporting conversion factors*. Retrieved from https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2026

DFFE. (2022, October 7). Methodological guidelines for Quantification of Greenhouse Gas Emissions. A companian to the South African National GHG Emission Reporting Regulations. Version No. MG-2022.1. *Government Gazette no 47257, MG-2022.1*. Pretoria, South Africa: DFFE.

DFFE. (2022). *Methodological Guidelines for Quantification of Greenhouse Gas Emissions: A companion to the South African National GHG Emission Reporting Regulations. Version No: MG-2022.1.* Pretoria: Government Gazette, 7 October 2022, No. 47257(2598), Department of Forestry, Fisheries and Environment.

DFFE. (2022a). *GHG Inventory Report for South Africa 2000 -2020.* DFFE. Retrieved 09 14, 2022, from https://www.dffe.gov.za/sites/default/files/gazetted_notices/8thnational-greenhouse-gasinventory-reportg47133gon2321.pdf

DFFE. (2025). *Publicatio of the 9th National Greenhouse Gas Inventory Report for the Republic of South Africa. GG No. 52067, 7 February 2025.* Department of Forestry, Fisheries and the Environment.

Duncker, L. (2018). *Green Book – The impact of climate changeon sanitation services provision within settlements.* Pretoria: CSIR.

Dunker, L., & Van Wyk, L. (2018). *Green Book – The impact of climate change on stormwater management within settlements.* CSIR.

Engelbrecht, F. (2019). *Technical Report: Green Book – Detailed Projections of Future. Report reference number: CSIR/BE/SPS/ER/2019/0005/C.* Pretoria: CSIR (Council for Scientific and Industrial Research).

Garland, R. (2018). *Green Book – The impact of climate changeon human health in settlements.* Pretoria: CSIR.

IPCC. (2007). *Intergovernmental Panel on Climate Change 4th Assessment Report.* Retrieved from Intergovernmental Panel on Climate Change: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_appendix.pdf

IPCC. (2013). *Intergovernmental Panel on Climate Change 5th Assessment Report.* Retrieved from Intergovernmental Panel on Climate Change: https://www.ipcc.ch/report/ar5/

IPPC. (2022). *IPCC WGI Interactive Atlas: Regional information (Advanced)*. Retrieved January 6, 2023, from https://interactive-atlas.ipcc.ch

Le Roux, A., van Niekerk, W., Arnold, K., Pieterse, A., Ludick, C., Forsyth, G., . . . Mans, G. (2019). *Green Book Risk Profile Tool.* (CSIR, Pretoria) Retrieved 09 30, 2022, from riskprofiles.greenbook.co.za

Mokonyama, M., & Van Wyk, L. (2018). *Green Book - Transport and mobility: the impact of climate change on transport and mobility within settlements.* CSIR.

Naidoo, S. (2018). *Green Book – The impact of climate change on ICT services provision within settlements. .* Pretoria: CSIR.

NOAA. (2021, September). *Earth System Research Laboratory Global Monitoring Division.* Retrieved from National Oceanic and Atmospheric Administration: https://gml.noaa.gov/ccgg/trends/global.html

Oelofse, S. (2018). *The impact of climate change on solid waste management within settlements.* CSIR.

Pieterse, A., & Crankshaw, B. (2018). *Green Book –The impact of climate change on ecosystem services in settlements.* Pretoria: CSIR.

Republic of South Africa. (2017, July 21). Declaration of Greenhouse Gases as Priority Pollutants. *Government Gazette 40996*. Pretoria, Gauteng, South Africa: Government Printing Works. Retrieved from www.gpw.co.za

Republic of South Africa. (2019, May 23). Carbon Tax Act 15 of 2019. *Government Gazette 42483*. Cape Town, Western Cape, South Africa: Government Printing Works. Retrieved from www.gpw.co.za

SAWS. (2017). *A Climate Change Reference Atlas 2017 - based on CMIP5 – CORDEX downscaling.* Pretoria, South Africa: South African Weather Service and the Water Research Commission. Retrieved from https://www.weathersa.co.za/home/climatechangeatlas

TCFD. (2017). *Implementing the Recommendations of the Task Force on Climate related Financial Disclosures.* Task Force on Climate related Financial Disclosures. Retrieved from https://www.fsb-tcfd.org/publications/final-implementing-tcfd-recommendations/

TCFD. (2020). *Task Force on Climate-related Financial Disclosures: Overview.* Task Force on Climate-related Financial Disclosures. Retrieved from https://www.fsb-tcfd.org/

Thambiran, T., & Naidoo, S. (2017). Chapter 14: Adaptation and Mitigation: Synergies and Trade-Offs. In C. Davis-Reddy, & K. Vincent, *Climate Risk and Vulnerability: A Handbook for Southern Africa (2nd Ed)* (pp. 138-147). Pretoria: CSIR.

Thambiran, T., & van Wyk, L. (2018). *Green Book – The impact of climate change on energy services provision within settlements.* Pretoria: CSIR.

UNFCCC. (2017). *United Nations Framework Convention on Climate Change e-Handbook* . Retrieved from United Nations Framework Convention on Climate Change: http://bigpicture.unfccc.int/

van Wyk, L. (2018). *Green Book – The impact of climate change on culture and heritage in settlements.* Pretoria: CSIR.

WRI & WBCSD. (2004). *The Greenhouse Gas Protocol - A Corporate Accounting and Reporting Standard.* Washington & Switzerland: WRI & WBCSD.

8 APPENDIX A – CURRICULUM VITAE OF ASSESSMENT AUTHOR

CURRICULUM VITAE (CV)

Position Title and No.	Managing Director and Principal Air Quality Scientist
Name of Expert:	Hanlie Liebenberg-Enslin
Date of Birth:	09 January 1971
Country of Citizenship/Residence	South Africa

Education: Ph.D Geography, University of Johannesburg, 2014
M.Sc Geography and Environmental Management, University of Johannesburg, 1999
BSc (Hons) Geography, University of Johannesburg, 1995
BSc, Geography and Geology, University of Johannesburg, 1994

Employment record relevant to the assignment:

Period	Employing organization and your title/position. Contact info for references	Country	Summary of activities performed relevant to the Assignment
March 2003 - Date	**Airshed Planning Professionals (Pty) Ltd** **Title/Position:** Managing Director and Principal Air Quality Scientist	South Africa	Air Quality Impact Assessments, Air Quality Management Plans, Dispersion modelling, Emissions quantification, Basic Assessments, Climate Change Assessments, Greenhouse Gas Quantification, Ambient Monitoring and evaluation, Project Management and control of budget, Regulations and procedures, Quality control, Liaison with Government, Public Entities, Non-governmental Organisations, and Private Sector Partners, Literature Reviews and
Jan 2000 - Feb 2003	Environmental Management Services CC **Title/Position:** Acting Senior Air Quality Scientist	South Africa	Air Quality Impact Assessments, Air Quality Management Plans, Dispersion modelling, Emissions quantification, Basic Assessments. Ambient Monitoring and evaluation.
May 1998 – Dec 1999	Independent Broadcasting Authority (IBA) **Title/Position:** GIS Analyst and Demographer	South Africa	Statistical analysis on demographics of the country, GIS mapping, database development.
Feb 1997 – Apr 1998	GIS Business Solutions (PQ Africa **Title/Position:** GIS Analysis	South Africa	Environmental analysis, assessment, and monitoring. Development and management. Geographic Information System.
Jan 1996 – Dec 1996	Annegarn Environmental Research (AER) **Title/Position:** Student Researcher	South Africa	Environmental analysis, assessment, and monitoring. Data analysis. Geographic Information System.

Membership in Professional Associations and Publications:

Memberships:

- International Union of Air Pollution Prevention and Environmental Protection Associations (IUAPPA) – President 2010–2013, Board member 2013-present
- Member of the National Association for Clean Air (NACA) - President 2008-2010, NACA Council member 2010 – 2014

Publications:

- Air Quality Evolution in South Africa over the past 20 years: A Consultants' Journey. Hanlie Liebenberg-Enslin. 55th Annual Conference of the National Association for Clean Air, 4 to 6 September 2024, Johannesburg. Keynote speaker
- Integrated Assessment of Air Pollution and Climate Change for Sustainable Development in Africa – Towards "the Africa we want". Hanlie Liebenberg-Enslin, and Kevin Hicks. Air Protection 2023 & International Conference and 13th Croatian Scientific and Professional Meeting, CAPPA, 20 - 24 September 2023, Dubrovnik, Croatia at Hotel Astarea, Mlini.
- Dust and radon levels on the west coast of Namibia – What did we learn? Hanlie Liebenberg-Enslin, Detlof von Oertzen, and Norwel Mwananawa. Atmospheric Pollution Research, 2020. https://doi.org/10.17159/caj/2020/30/1.8467
- Understanding the Atmospheric Circulations that lead to high particulate matter concentrations on the west coast of Namibia. Hanlie Liebenberg-Enslin, Hannes Rauntenbach, Reneé von Gruenewaldt, and Lucian Burger. Clean Air Journal, 27, 2, 2017, 66-74.
- Cooperation on Air Pollution in Southern Africa: Issues and Opportunities. SLCPs: Regional Actions on Climate and Air Pollution. Liebenberg-Enslin, H. 17th IUAPPA World Clean Air Congress and 9th CAA Better Air Quality Conference. Clean Air for Cities - Perspectives and Solutions. 29 August - 2 September 2016, Busan Exhibition and Convention Center, Busan, South Korea.
- A Best Practice prescription for quantifying wind-blown dust emissions from Gold Mine Tailings Storage Facilities. Liebenberg-Enslin, H., Annegarn, H.J., and Burger, L.W. VIII International Conference on Aeolian Research, Lanzhou, China. 21-25 July 2014.
- Quantifying and modelling wind-blown dust emissions from gold mine tailings storage facilities. Liebenberg-Enslin, H. and Annegarn, H.J. 9th International Conference on Mine Closure, Sandton Convention Centre, 1-3 October 2014.
- Gauteng Transport Air Quality Management Plan. Liebenberg-Enslin, H., Krause,N., Burger, L.W., Fitton, J. and Modisamongwe, D. National Association for Clean Air Annual Conference, Rustenburg. 31 October to 2 November 2012. Peer reviewed.
- Developing an Air Quality Management Plan: Lessons from Limpopo. Bird, T.; Liebenberg-Enslin, H., von Gruenewaldt, R., Modisamongwe, D. National Association for Clean Air Annual Conference, Rustenburg. 31 October to 2 November 2012. Peer reviewed.
- Modelling of wind eroded dust transport in the Erongo Region, Namibia, H. Liebenberg-Enslin, N Krause and H.J. Annegarn. National Association for Clean Air (NACA) Conference, October 2010. Polokwane.
- The lack of inter-discipline integration into the EIA process-defining environmental specialist synergies. H. Liebenberg-Enslin and LW Burger. IAIA SA Annual Conference, 21-25 August 2010. Workshop Presentation. Not Peer Reviewed.
- A Critical Evaluation of Air Quality Management in South Africa, H Liebenberg-Enslin. National Association for Clean Air (NACA) IUAPPA Conference, 1-3 October 2008. Nelspuit.

- Vaal Triangle Priority Area Air Quality Management Plan – Baseline Characterisation, R.G. Thomas, H Liebenberg-Enslin, N Walton and M van Nierop. National Association for Clean Air (NACA) conference, October 2007, Vanderbijl Park.
- Air Quality Management plan as a tool to inform spatial development frameworks – City of uMhlathuze, Richards Bay, H Liebenberg-Enslin and T Jordan. National Association for Clean Air (NACA) conference, 29 – 30 September 2005, Cape Town.

Language Skills (indicate only languages in which you can work):

Language	Speaking	Reading	Writing
English	Excellent	Excellent	Excellent
Afrikaans	Excellent	Excellent	Excellent

Adequacy for the Assignment:

Detailed Tasks Assigned on Consultant's Team of Experts:	Reference to Prior Work/Assignments that Best Illustrates Capability to Handle the Assigned Tasks
Policy development relating to the use of cleaner fuels	Technical Project Manager on **Developing a Controlled Fuels Policy for the City of eThekwini:** The aim of the controlled fuel ban policy development project is to establish a policy that will address the poor air quality in the city (2023 – 2024). Project included: • A 'controlled fuels' source inventory, with associated ratings (high, medium, low) and visually displayed on a map. • A definition of 'controlled fuels'. • A framework document regarding legal instruments available. • A baseline 'controlled fuels' emissions inventory for the City of eThekwini. • Draft Implementation Plan, including policy recommendations and impact analysis. • Validation Workshop Report. • A draft and final Project
Air Quality Management Plans	Technical Project Manager on **The Second Generation Vaal Triangle Airshed Priority Area Air Quality Management Plan for the Department of Environment, Forestry and Fisheries (2017 – 2020)**. Project included: • Baseline Assessment • Dispersion modelling • Meteorological and ambient data analysis and reporting • Emissions quantification • Air quality impact assessment • Air quality management plan development

Strategic Environmental Assessments	Technical Project Manager on **The Advanced Air Quality Management for the Strategic Environmental Management Plan for the Uranium and Other Industries in the Erongo Region (2016 – 2019)**. Description of actual services provided by your staff within the assignment: • Dispersion modelling • Meteorological and ambient data analysis and reporting • Emissions quantification • Air quality impact assessment • Air quality management plan development • Air quality guidelines recommendations
Air Quality Impact Assessment for a Biomass Power Plant	Air quality Impact assessment as part of the Environmental Impact Assessment (EIA) for the proposed Encroacher Bush Biomass Power Project in Namibia (2019), project done for SLR Consulting (Namibia) (Pty) Ltd.
Air Quality Impact Assessment for a pipleline	Air Quality Impact Assessment for the Proposed Expansion Project Phase IV Project, the Conversion of the EPL500 to a ML, new Water Pipeline and upgrading the Power Supply at Langer Heinrich Mine, Namibia (2011) project done for Metago Environmental Engineers

Greenhouse Gas Emissions Foot-printing and Climate Change Impact Statements	**PV Solar Plants** • Quantified the direct and indirect (due to imported electricity) emissions for a number of Solar PV Plants in South Africa (Britstown Solar PV Cluster 1-6: Soyuz 5 Solar PV Park; Solesberg Solar PV Farm in Limpopo Province). • Assessed the climate risks and vulnerabilities of the project and surrounding communities due to increasing ambient temperatures, water scarcity, risk of intense storms.
	Natural Gas Fields • Quantified the direct and indirect (due to imported electricity) emissions for Phase 2 of the Gas Gathering Project in Virginia, South Africa. Avoided emissions from coal-fired power plants were also considered. • Assessed the climate risks and vulnerabilities of the project and surrounding communities due to increasing ambient temperatures; risk of intense storms, including tropical cyclones; sea level rise and coastal stability.
	Mining • Quantified the direct and indirect (due to imported electricity) emissions for a mine waste disposal facility and mining opencast mining operations in Namibia (Okorusu Processing and Waste Disposal Site and Okanjande Graphite Mine). • Assessed the climate risks and vulnerabilities of the project and surrounding communities due to increasing ambient temperatures, water scarcity, risk of intense storms.

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Certification:

I, the undersigned, certify that to the best of my knowledge and belief, this CV correctly describes myself, my qualifications, and my experience, and I am available to undertake the assignment in case of an award. I understand that any misstatement or misrepresentation described herein may lead to my disqualification or dismissal by the Client.



Hanlie Liebenberg-Enslin		28/08/2026
Name of Expert	Signature	Date

9 APPENDIX B – DECLARATION OF INDEPENDENCE

10 APPENDIX C – EMISSION FACTORS

Emission factors	Emission Factors			Unit	Source	Comment	Reference document
Scope 1 - Direct Emissions							
	CO_2	CH_4	N_2O				
diesel - stationary combustion	74638	3	0.6	kg CO_2/TJ	Table A.1 & Table A.3 (Methodological Guidelines, GG47257, 7Oct2022)	Diesel oil	Methodological Guidelines for Quantfication of Greenhouse Gas Emissions (Version No: MG-2022.1), Table A.3
diesel - mobile combustion	74638	4.15	28.6	kg CO_2/TJ	Table A.2 & Table A.3 (Methodological Guidelines, GG47257, 7Oct2022)	Diesel oil	Methodological Guidelines for Quantfication of Greenhouse Gas Emissions (Version No: MG-2022.1), Table A.3
diesel - mobile combustion (offroad)	74638	4.15	28.6	kg CO_2/TJ	Table A.2 & Table A.3 (Methodological Guidelines, GG47257, 7Oct2022)		
petrol - mobile combustion	72430	3.5	5.7	kg CO_2/TJ	Table A.2 & Table A.3 (Methodological Guidelines, GG47257, 7Oct2022)		
LPG - stationary combustion	63100	1.0	0.1	kg CO_2/TJ	Table A.1 & Table A.3 (Methodological Guidelines, GG47257, 7Oct2022)	AGO factors and methods workbook 2008 (Australia)	2.) Blasting agent (ANFO) scope 1 emission factor
Lubricants - stationary combustion	73300	3.0	0.6	kg CO_2/TJ	Table A.1 (Methodological Guidelines, GG47257, 7Oct2022)		
Lubricants - mobile combustion	73300	3.0	0.6	kg CO_2/TJ	Table A.1 (Methodological Guidelines, GG47257, 7Oct2022)		
Scope 2 - Indirect Emissions							
Electricity	0.9310			tonne CO_2e per MWh	South Africa's 2022 Grid Emission Factors Report	Coal generated electricity	South Africa's 2022 Grid Emission Factors Report, Table 1
Scope 3 - Indirect Emissions							
3.1 Purchased goods							
Water supply	0.1913			kg CO_2e per m^3	Department for Environment, Food and Rural Affairs (DEFRA) 2025	Includes indirect effects of non-CO_2 emissions	DEFRA EF (published 8 July 2024 and last updated 30 October 2024)
Water treatment	0.1709			kg CO_2e per m^3	Department for Environment, Food and Rural Affairs (DEFRA) 2025		
aggregates (construction)	7.8031			kg CO_2e per tonnes	Department for Environment, Food and Rural Affairs (DEFRA) 2025		
concrete (constructon)	118.803			kg CO_2e per tonnes	Department for Environment, Food and Rural Affairs (DEFRA) 2025		
metals (construction)	3821.949			kg CO_2e per tonnes	Department for Environment, Food and Rural Affairs (DEFRA) 2025		

Emission factors	Emission Factors			Unit	Source	Comment	Reference document
High-calcium lime	0.75			kg CO_2e per tonnes	https://www.climatiq.io/data/emission-factor/3cb041f3-410e-4659-a797-1c06df7500cb		
Active NaCN	3.5			kg CO_2e per tonnes	https://www.climatiq.io/data/emission-factor/d12381f7-0170-4bce-80e0-e6afc040cdfd		
Oxygen	0.2			kg CO_2e per tonnes	https://www.climatiq.io/data/emission-factor/28c52040-a4c4-4b9f-b3f4-8d573a742192		
Caustic soda (NaOH)	1.2			kg CO_2e per tonnes	https://apps.carboncloud.com/climatehub/product-reports/id/183314951001		
Hydrochloric acid (HCl)	0.9			kg CO_2e per tonnes	https://apps.carboncloud.com/climatehub/product-reports/id/6771589699675		
Activated carbon	10.0			kg CO_2e per tonnes	https://apps.carboncloud.com/climatehub/product-reports/id/2249085474186		
Flocculent (PAM)	4.0			kg CO_2e per tonnes	https://www.climatiq.io/data/emission-factor/abd17a7b-51d7-4e02-8545-45666725da4a_29f75a6a-e5cd-40f6-8f84-797deb0ef98c		
3.2 Capital goods/ assets (incoming)							
electrical items - large [for equipment uchased]	3267.00			kg CO_2e per tonnes			
average construction [for materials purchased]	74.996			kg CO_2e per tonnes			
3.3 Fuel and Energy-Related Activities							
Petrol (average biofuel blend)	0.581			kg CO_2e per litres	Department for Environment, Food and Rural Affairs (DEFRA) 2025		
Diesel (average biofuel blend)	0.611			kg CO_2e per litres	Department for Environment, Food and Rural Affairs (DEFRA) 2025		
LPG	349.293			kg CO_2e per tonnes	Department for Environment, Food and Rural Affairs (DEFRA) 2025		
Welding gas	3.380			kg CO_2e per tonnes	LWB calculation based on 100% acetylene		
Lubricants	1116.837			kg CO_2e per tonnes	Department for Environment, Food and Rural Affairs (DEFRA) 2025		
3.4 Upstream transportation							
Rigid (>17 tonnes)	0.998			kg CO_2e per km	Department for Environment, Food and Rural Affairs (DEFRA) 2025		
Articulated (>3.5 - 33t)	0.789			kg CO_2e per km	Department for Environment, Food and Rural Affairs (DEFRA) 2025		
Articulated (>33t)	0.939			kg CO_2e per km	Department for Environment, Food and Rural Affairs (DEFRA) 2025		

Emission factors	Emission Factors			Unit	Source	Comment	Reference document
Average non-refrigerated rigids	0.846			kg CO_2e per km	Department for Environment, Food and Rural Affairs (DEFRA) 2025		
3.5 Waste generated							
commercial and industrial waste (to landfill)	520.58			kg CO_2e per tonne	Department for Environment, Food and Rural Affairs (DEFRA) 2025		DEFRA EF (published 8 July 2024 and last updated 30 October 2024)
household residual waste [for office waste]	497.29			kg CO_2e per tonne	Department for Environment, Food and Rural Affairs (DEFRA) 2025		
mineral oil (to combustion) [for lubricant oil (third party disposal)]	4.654			kg CO_2e per tonne	Department for Environment, Food and Rural Affairs (DEFRA) 2025		
average construction (to combustion) [for hazardous waste (third party disposal)]	4.654			kg CO_2e per tonne	Department for Environment, Food and Rural Affairs (DEFRA) 2025		DEFRA EF (published 8 July 2024 and last updated 30 October 2024)
3.6 Business travel							
car - Dual purpose 4x4 - diesel	0.1979			kg CO_2e per km	Department for Environment, Food and Rural Affairs (DEFRA) 2024	Includes indirect effects of non-CO_2 emissions	DEFRA EF (published 8 July 2024 and last updated 30 October 2024)
car - sedan (petrol)	0.1741			kg CO_2e per km	Department for Environment, Food and Rural Affairs (DEFRA) 2024	Includes indirect effects of non-CO_2 emissions	DEFRA EF (published 8 July 2024 and last updated 30 October 2024)
business air travel - economy class - international	0.1092			kg CO_2e per passenger.km	Department for Environment, Food and Rural Affairs (DEFRA) 2024	Includes indirect effects of non-CO_2 emissions	DEFRA EF (published 8 July 2024 and last updated 30 October 2024)
business air travel - economy class - domestic	0.2293			kg CO_2e per passenger.km	Department for Environment, Food and Rural Affairs (DEFRA) 2024	Includes indirect effects of non-CO_2 emissions	DEFRA EF (published 8 July 2024 and last updated 30 October 2024)
3.7 Employee commuting							
Bus	0.1255			kg CO_2e per passenger.km			
MPV (used for Minibus taxi)	0.1798			kg CO_2e per km			
medium car (for private vehicles)	0.1741			kg CO_2e per km			
motorbike (average)	0.1137			kg CO_2e per km			
3.9 Downstream transportation							

Emission factors	Emission Factors			Unit	Source	Comment	Reference document
freighting goods - Van (average up to 3.5 tonnes) - diesel	0.6351			kg CO_2e per tonne.km	Department for Environment, Food and Rural Affairs (DEFRA) 2024	Includes indirect effects of non-CO_2 emissions	DEFRA EF (published 8 July 2024 and last updated 30 October 2024)
freighting goods - helicopter	2.0			kg CO_2e per tonne.km	https://www.cargo-stack.com/tools/co2e-calculator/	Includes indirect effects of non-CO_2 emissions	DEFRA EF (published 8 July 2024 and last updated 30 October 2024)
3.11 Use of sold products							
GHG emissions from production of gold	792			kg CO_2e per oz gold	Internet - see summary on the right		
Conversion factors	**Value**			**Unit**	**Source**	**Comment**	**Reference document**
Diesel calorific value	0.000036			TJ/litre	SA Technical Guidelines - Table D1	Diesel oil	Volume 2, Chapter 1, Table 1.2
Diesel - density	0.8255			kg/l	SA Technical Guidelines - Table D1	Annexure D	Methodological Guidelines for Quantfication of Greenhouse Gas Emissions (Version No: MG-2022.1)
Petrol calorific value	0.000033			TJ/litre	SA Technical Guidelines - Table D1		
Petrol - density	0.7405			kg/l	SA Technical Guidelines - Table D2		
LPG calorific value	0.0834			TJ/tonne			
LPG - density	0.555			kg/l			
Lubricants calorific value	0.040			TJ/tonne			
CH_4 GWP (100 year time horizon)	23			tonne CO_2e/tonne CH_4	SA Technical Guidelines	Global Warming Potential Values	Annexure G
N_2O GWP (100 year time horizon)	296			tonne CO_2e/tonne N_2O	SA Technical Guidelines	Global Warming Potential Values	Annexure G

11 APPENDIX D – OPERATIONAL INFORMATION

11.1 Current Operations

Scope 1 - CO2 generated due to activities		Fuel use	Units	Backfill related water related, Savuka residue to plant
Mobile fuel combustion (cars, vans, forklifts, trucks, etc) (Company-owned vehicles)	Petrol	2 920	litres/year	Forklift
	Diesel	45 055	litres/year	Crane
	LPG	N/A	kg/year	LDV
	Lubricants	0.5	tonnes/year	
Stationary fuel combustion	Gas	N/A	m³/year	
	Diesel	Negligible	litres/year	Generator
	Bituminous coal	N/A	tonnes/year	
	LPG	N/A	kg/year	
	Explosives	N/A	tonnes/year	

Scope 2 - CO2 generated due to activities			
	Elec use	Units	
Electricity consumed	21 024 000	kWh/year	grid Eskom power - Backfill plant
(confirm if grid or renewable)	Grid	grid	

	Scope 3 - CO2 generated externally due to activities					
Category	Category name	Category description		Units		
1	Purchased goods and services	i.e. water consumption	876	kl/year	potable and process	
		e.g. concrete needed for contruction	N/A	tonnes/year		
		e.g. steel needed for contruction	N/A	tonnes/year		
2	Capital goods/ assets (incoming)					
	(Capital goods are final products that have an extended life and	e.g. machinary purchased	Neglibible	tonnes/year	Weight transported to plant re maintenance or spares related to backfill/WW operation	
	are used by the company to manufacture a product;	e.g. equipment purchased	5	tonnes/year		
	provide a service; or sell, store, and deliver merchandise.)	e.g. materials purchased	Negligible			
3	Fuel- and Energy related activities not included in Scope 1 & 2	Petrol	Included in Scope 1	litres/year		
	(this would inlcude fuel used by contractors for mobile and stationary equipment)	Diesel	Included in Scope 1	litres/year	Current number of contract people - majority public transport plus private vehicles	
		LPG	N/A	kg/year		
		gas	N/A	m^3/year		
		Bituminous coal	N/A	tonnes/year		
		Lubricants	Inclued in Scope 1	tonnes/year		
		Mode transport (rail, air, sea, road)	Size vehicle/sea tanker/cargo ship	Fuel type	Total km per year	Type of transport and distances re maintenance or spares purchased related to backfill (agent/supplier - not manufacturer)
4	Upstream transportation					
	•• Transportation and distribution of products purchased in the reporting year, between a company's tier 1 suppliers3 and its own operations in vehicles not owned or operated by the reporting company (including multi-modal shipping where multiple carriers are involved in the delivery of a product, but excluding fuel and energy products) •• Third-party transportation and distribution services purchased by the reporting company in the reporting year (either directly or through an intermediary), including inbound logistics, outbound logistics (e.g., of sold products), and third-party transportation and distribution between a company's own facilities.	Road	Mechanical spares (Johannesburg) Electrical & instrumentation Lubricants & consumables General hardware (Carletonville) Forklift LPG/diesel cylinders & supplies Hired mobile cranes. 8–16 t flatbed 3–8 t rigid truck 1–3 t delivery truck 1 t LDV Light truck 40–80 t crane	Diesel	28 000	
5	Waste generated			Units	How is waste treated?	
	(Indicate if waste is sent to landfill, recycled, combusted?)	industrial waste	20.2	tonnes/year	Waste separation, landfill	Steel, rubber, copper etc
		office waste	3	tonnes/year	Landfill	Domestic waste/tea rooms/offices
		lubricant oil	1.5	tonnes/year		
		hazardous waste	0	tonnes/year		
		coal/ash	N/A	tonnes/year		
		etc				
6	Business travel					
	Emissions from transportation in vehicles owned or controlled by the reporting company are accounted for in either scope 1 (for fuel use), or in the case of electric vehicles, scope 2 (for electricity use). Emissions from leased vehicles operated by the reporting company not included in scope 1 or scope 2 are accounted for in scope 3, category 8 (Upstream leased assets). Emissions from transportation of employees to and from work are accounted for in scope 3, category 7 (Employee commuting).	Engine size	Fuel type	Total km per year		
	Rental vehicles	Double-cab LDV - 2L	Diesel	20 000		
		Rental sedan - 1400kw	Petrol	5 000		
		Route	Number of flights per route	Class	Km per route	
	Business flights	N/A	N/A	N/A	N/A	
		Mode transport (rail, air, sea, vehicle)	Size vehicle/sea tanker/cargo ship	Fuel type	Total km per year	
	Transportation of product (if 3rd party)	N/A	N/A	N/A	N/A	
7	Employee commuting	Mode transport (bus, car)	Size vehicle/bus	Fuel type	Total km per year	
	This category includes emissions from the transportation of emplo	minibus	24	Diesel	187 200	21.37
		car	10	Petrol	78 000	21.37
		motor cycles/other	2	Petrol	15 600	21.37
9	Downstream transportation	Mode transport (rail, air, sea, vehicle)	Size vehicle/sea tanker/cargo ship	Tonnes/year	Total km per year	
	This category also includes emissions from retail and storage.	N/A	N/A	N/A	N/A	
		N/A	N/A	N/A	N/A	
		Production rate	Units	Use of product		
11	Use of sold products	N/A	N/A	N/A		

11.2 Construction Phase – TSF

	Scope 1 - CO2 generated due to activities		Fuel use	Units	Project activities done by contractors.
	Mobile fuel combustion (cars, vans, forklifts, trucks, etc) (Company-owned vehicles)	Petrol	N/A	litres/year	
		Diesel	N/A	litres/year	
		LPG	N/A	kg/year	
		Lubricants	N/A	tonnes/year	
	Stationary fuel combustion	Gas	N/A	m^3/year	
		Diesel	N/A	litres/year	
		Bituminous coal	N/A	tonnes/year	
		LPG	N/A	kg/year	
		Explosives	N/A	tonnes/year	
	Scope 2 - CO2 generated due to activities				
		Elec use	Units		
	Electricity consumed	N/A	kWh/year		Project activities done by contractors - existing grid and consumption
	(confirm if grid or renewable)	N/A	grid		assumed similar due to small usage (construction equipment, addition tea
	Scope 3 - CO2 generated externally due to activities				
Category	Category name	Category description		Units	
1	Purchased goods and services	i.e. water consumption	14 600	kl/year	potable only, potable for ablutions - see assumptions
		e.g materials (waste, G5, burrow pit, crusher rock)	2 000 000	tonnes/year	Total design requirement - total quantities/yrs of construction
		e.g. concrete needed for contruction	1 895	tonnes/year	Total design requirement - total quantities/yrs of construction
		e.g. steel needed for contruction	471	tonnes/year	Total design requirement - total quantities/yrs of construction
2	Capital goods/ assets (incoming)				
	(Capital goods are final products that have an extended life and are used by the company to manufacture a product; provide a service; or sell, store, and deliver merchandise.)	e.g. machinary purchased	N/A	tonnes/year	Contractor uses own machinary, existing machinary assumed to be used.
		e.g. equipment purchased	71	tonnes/year	Weight transported for all equipmentdelivered
		e.g. materials purchased	7.3	tonnes/year	Weight transported for all materials delivered
3	Fuel- and Energy related activities not included in Scope 1 & 2	Petrol	54 800	litres/year	2-2.5 years consruction
	(this would inlcude fuel used by contractors for mobile and stationary equipment)	Diesel	3 040 000	litres/year	2-2.5 years consruction
		LPG	N/A	kg/year	
		gas	N/A	m^3/year	
		Bituminous coal	N/A	tonnes/year	
		Lubricants	96000	tonnes/year	2-2.5 years consruction
		Mode transport (rail, air, sea, vehicle)	Size vehicle/sea tanker/cargo ship	Fuel type	Total km per year

4	**Upstream transportation**				
	•• Transportation and distribution of products purchased in the reporting year, between a company's tier 1 suppliers3 and its own operations in vehicles not owned or operated by the reporting company (including multi-modal shipping where multiple carriers are involved in the delivery of a product, but excluding fuel and energy products) •• Third-party transportation and distribution services purchased by the reporting company in the reporting year (either directly or through an intermediary), including inbound logistics, outbound logistics (e.g., of sold products), and third-party transportation and distribution between a company's own facilities.	Majority of construction materials and capital equipment will be delivered via road transport. Refer to sheet TSF assumptions D362.	Refer to sheet TSF assumptions D and E 362	Refer to sheet TSF assumptions F362.	475 720
5	**Waste generated**			**Units**	**How is waste treated?**
	(Indicate if waste is sent to landfill, recycled, combusted?)	industrial waste	5.5	tonnes/year	Waste separation onsite, to apporved landfill of third party waste managem
		office waste	2.1	tonnes/year	Landfill
		lubricant oil	Refer to Sheet TSF assumptions B409-B414	tonnes/year	Refer to Sheet TSF assumptions B400-B407
		hazardous waste	25.1	tonnes/year	
		coal/ash	N/A	tonnes/year	
		etc			
6	**Business travel**				
	Emissions from transportation in vehicles owned or controlled by the reporting company are accounted for in either scope 1 (for fuel use), or in the case of electric vehicles, scope 2 (for electricity use). Emissions from leased vehicles operated by the reporting company not included in scope 1 or scope 2 are accounted for in scope 3, category 8 (Upstream leased assets). Emissions from transportation of employees to and from work are accounted for in scope 3, category 7 (Employee commuting).	**Engine size**	**Fuel type**	**Total km per year**	
	Rental vehicles	N/A	N/A	N/A	N/A
		Route	**Number of flights per route**	**Class**	**Km per route**
	Business flights	N/A	N/A	N/A	N/A
		Mode transport (rail, air, sea, vehicle)	**Size vehicle/sea tanker/cargo ship**	**Fuel type**	**Total km per year**
	Transportation of product (if 3rd party)	N/A	N/A	N/A	N/A
7	**Employee commuting - Contractors commuting**	**Mode transport (bus, car)**	**Size vehicle/bus**	**Fuel type**	**Total km per year**
	This category includes emissions from the transportation of employees between their homes and their worksites.	Refer to sheet TSF assumptions A429	Refer to sheet TSF assumptions D429	Refer to sheet TSF assumptionsB442-446	Refer to sheet TSF assumptions A456
9	**Downstream transportation**	**Mode transport (rail, air, sea, vehicle)**	**Size vehicle/sea tanker/cargo ship**	**Tonnes/year**	**Total km per year**
	This category also includes emissions from retail and storage.	N/A	N/A	N/A	N/A
		N/A	N/A	N/A	N/A
		Production rate	**Units**	**Use of product**	
11	**Use of sold products**	N/A	N/A	N/A	

11.3 Construction Phase – Plant

	Scope 1 - CO2 generated due to activities		Fuel use	Units	Project activities done by contractors.
	Mobile fuel combustion (cars, vans, forklifts, trucks, etc) (Company-owned vehicles)	Petrol	N/A	litres/year	
		Diesel	N/A	litres/year	
		LPG	N/A	kg/year	
		Lubricants	N/A	tonnes/year	
	Stationary fuel combustion	Gas	N/A	m^3/year	
		Diesel	N/A	litres/year	
		Bituminous coal	N/A	tonnes/year	
		LPG	N/A	kg/year	
		Explosives	N/A	tonnes/year	
	Scope 2 - CO2 generated due to activities				
		Elec use	Units		
	Electricity consumed	N/A	kWh/year		Project activities done by contractors - existing grid and consumption assumed similar due to small usage (construction
	(confirm if grid or renewable)	N/A	grid		equipment, addition tea tooms/offices) - negligible. Generators and solar power to be utilised.
	Scope 3 - CO2 generated externally due to activities				
Category	Category name	Category description		Units	
1	Purchased goods and services	i.e. water consumption	15 148	kl/year	potable only, potable for ablutions, drinking
		e.g materials (waste, G5, burrow pit, crusher rock)	130 600	tonnes/year	Total design requirement - total quantities/yrs of construction
		e.g. concrete needed for contruction	13 100	tonnes/year	Total design requirement - total quantities/yrs of construction
		e.g. steel needed for contruction	1 535	tonnes/year	Total design requirement - total quantities/yrs of construction
2	Capital goods/ assets (incoming)				
	(Capital goods are final products that have an extended life and are used by the company	e.g. machinary purchased	N/A	tonnes/year	Contractor uses own machinary, existing machinary assumed to be used.
	to manufacture a product;	e.g. equipment purchased	3 543	tonnes/year	Weight transported for all equipment, materials, machinery delivered
	provide a service; or sell, store, and deliver merchandise.)	e.g. materials purchased	N/A		Weight transported for all equipment, materials, machinery delivered
3	Fuel- and Energy related activities not included in Scope 1 & 2	Petrol	71 000	litres/year	
	(this would inlcude fuel used by contractors for mobile and stationary equipment)	Diesel	492 000	litres/year	Site/project related
		LPG	1 200	kg/year	
		Welding gas	3	t/year	
		Bituminous coal	N/A	tonnes/year	
		Lubricants	4.3	tonnes/year	
		Mode transport (rail, air, sea, vehicle)	Size vehicle/sea tanker/cargo ship	Fuel type	Total km per year
4	Upstream transportation				
	•• Transportation and distribution of products purchased in the reporting year, between a company's tier 1 suppliers3 and its own operations in vehicles not owned or operated by the reporting company (including multi-modal shipping where multiple carriers are involved in the delivery of a product, but excluding fuel and energy products) •• Third-party transportation and distribution services purchased by the reporting company in the reporting year (either directly or through an intermediary), including inbound logistics, outbound logistics (e.g., of sold products), and third-party transportation and distribution between a company's own facilities.	Refer to Assumptions Row 310	Refer to Assumptions Row 310	Refer to Assumptions Row	100 450
5	Waste generated			Units	How is waste treated?
	(Indicate if waste is sent to landfill, recycled, combusted?)	industrial waste	916	tonnes/2.5 year	Waste separation, landfill
		office waste	125	tonnes/2.5 year	Landfill
		lubricant oil	15	tonnes/2.5 year	Thrid party/licensed disposal
		hazardous waste	35	tonnes/2.5 year	Thrid party/licensed disposal
		coal/ash	N/A	tonnes/year	
		etc			

6	**Business travel**				
	Emissions from transportation in vehicles owned or controlled by the reporting company are accounted for in either scope 1 (for fuel use), or in the case of electric vehicles, scope 2 (for electricity use). Emissions from leased vehicles operated by the reporting company not included in scope 1 or scope 2 are accounted for in scope 3, category 8 (Upstream leased assets). Emissions from transportation of employees to and from work are accounted for in scope 3, category 7 (Employee commuting).	**Engine size**	**Fuel type**	**Total km per year**	
	Rental vehicles	1200 sedans	Petrol	16 000.00	Minimal as most would use company vehicles for approx 10 people
		Route	**Number of flights per route**	**Class**	**Km per route**
	Business flights	Assumed passenger km's per annum	12 domestic return flights, 2 international return flights	Economy	45,200 passenger-km/year
		Mode transport (rail, air, sea, vehicle)	**Size vehicle/sea tanker/cargo ship**	**Fuel type**	**Total km per year**
	Transportation of product (if 3rd party)	N/A	N/A	N/A	N/A
7	**Employee commuting - Contractors commuting**	**Mode transport (bus, car)**	**Size vehicle/bus**	**Fuel type**	**Total km per year**
	This category includes emissions from the transportation of employees between their home	Contractor buses	50 passengers	**Diesel**	37 500
		Minibus taxis	15 passengers	Diesel	112 500
		Private vehicles	2 persons/vehicle	Petrol	472 500
9	**Downstream transportation**	**Mode transport (rail, air, sea, vehicle)**	**Size vehicle/sea tanker/cargo ship**	**Tonnes/year**	**Total km per year**
	This category also includes emissions from retail and storage.	N/A	N/A	N/A	N/A
		N/A	N/A	N/A	N/A
		Production rate	**Units**	**Use of product**	
11	**Use of sold products**	N/A	N/A	N/A	

11.4 Future Project Operations

	Scope 1 - CO2 generated due to activities		Fuel use	Units	Backfill related water related, Savuka residue to plant WWR operation
	Mobile fuel combustion (cars, vans, forklifts, trucks, etc) (Company-owned vehicles)	Petrol	4000	litres/year	Forklift
		Diesel	52000	litres/year	Crane
		LPG	N/A	kg/year	LDV
		Lubricants	3.65	tonnes/year	
	Stationary fuel combustion	Gas	N/A	m³/year	Generator
		Diesel	1 152 000.00	litres/year	
		Bituminous coal	N/A	tonnes/year	
		LPG	1200	kg/year	
		Explosives	N/A	tonnes/year	
	Scope 2 - CO2 generated due to activities				
		Elec use	Units		
	Electricity consumed	133 420 800	kWh/year		grid Eskom power - Backfill plant and WWR operations
		174 380 800			
	(confirm if grid or renewable)	Grid	grid		
	Scope 3 - CO2 generated externally due to activities				
Category	Category name	Category description		Units	
1	Purchased goods and services	i.e. water consumption	240 900.00	kl/year	Design criteria
		e.g. concrete needed for contruction	N/A	tonnes/year	
		e.g reagents needed for operation	20 000 - 25000	tonnes/year	
		Lime	11379	tonnes/year	24427.5
		Cyanide active NaCN	2640	tonnes/year	
		Oxygen	6300	tonnes/year	
		Caustic 48%	3053	tonnes/year	
		HCl 33%	622	tonnes/year	
		Carbon	396	tonnes/year	
		Floc	37.5	tonnes/year	
		e.g. steel needed for contruction	N/A	tonnes/year	
2	Capital goods/ assets (incoming)				
	(Capital goods are final products that have an extended life and are used by the company to manufacture a product; provide a service; or sell, store, and deliver merchandise.)	e.g. machinary purchased	N/A	tonnes/year	Existing plant machinery available.
		e.g. equipment purchased	430	tonnes/year	Weight transported to plant re maintenance or spares related to backfill/WW operation
		e.g. materials purchased	700	tonnes/year	
3	Fuel- and Energy related activities not included in Scope 1 & 2	Petrol	4000	litres/year	
	(this would inlcude fuel used by contractors for mobile and stationary equipment)	Diesel	304000	litres/year	Current number of contract people - majority public transport plus private vehicles
		LPG	1200	kg/year	
		gas	N/A	m³/year	
		Bituminous coal	N/A	tonnes/year	
		Lubricants	3.65	tonnes/year	

		Mode transport (rail, air, sea, vehicle)	**Size vehicle/sea tanker/cargo ship**	**Fuel type**	**Total km per year**
4	**Upstream transportation**				
	•• Transportation and distribution of products purchased in the reporting year, between a company's tier 1 suppliers3 and its own operations in vehicles not owned or operated by the reporting company (including multi-modal shipping where multiple carriers are involved in the delivery of a product, but excluding fuel and energy products) •• Third-party transportation and distribution services purchased by the reporting company in the reporting year (either directly or through an intermediary), including inbound logistics, outbound logistics (e.g., of sold products), and third-party transportation and distribution between a company's own facilities.	Road	20 t/container 25–30 t tanker 33 t tanker 20 t flatbed 20 t truck	Diesel	7.3 million tonne-km/year
5	**Waste generated**			**Units**	**How is waste treated?**
	(Indicate if waste is sent to landfill, recycled, combusted?)	industrial waste	212	tonnes/year	Waste separation, landfill
		office waste	66	tonnes/year	Landfill
		lubricant oil	7.5	tonnes/year	Waste separation, central salvage and 3rd party disposal
		hazardous waste	28	tonnes/year	Waste separation, central salvage and 3rd party disposal
		coal/ash	N/A	tonnes/year	
		etc			
6	**Business travel**				
	Emissions from transportation in vehicles owned or controlled by the reporting company are accounted for in either scope 1 (for fuel use), or in the case of electric vehicles, scope 2 (for electricity use). Emissions from leased vehicles operated by the reporting company not included in scope 1 or scope 2 are accounted for in scope 3, category 8 (Upstream leased assets). Emissions from transportation of employees to and from work are accounted for in scope 3, category 7 (Employee commuting).	**Engine size**	**Fuel type**	**Total km per year**	
	Rental vehicles	1200 sedans	Petrol	16 000.00	Minimal as most would use company vehicles for approx 10 people
		Route	**Number of flights per route**	**Class**	**Km per route**
	Business flights	N/A	N/A	N/A	N/A
		Mode transport (rail, air, sea, vehicle)	**Size vehicle/sea tanker/cargo ship**	**Fuel type**	**Total km per year**
	Transportation of product (if 3rd party)	N/A	N/A	N/A	N/A
7	**Employee commuting**	**Mode transport (bus, car)**	**Size vehicle/bus**	**Fuel type**	**Total km per year**
	This category includes emissions from the transportation of employees between their h	minibus	15	diesel	450 225.00
		bus/shuttle	50	petrol	250 125.00
		car	2	diesel	100 050.00
9	**Downstream transportation**	**Mode transport (rail, air, sea, vehicle)**	**Size vehicle/sea tanker/cargo ship**	**Tonnes/year**	**Total km per year**
	This category also includes emissions from retail and storage.	Air	Helicopter	0.2	8640
		Production rate	**Units**	**Use of product**	
11	**Use of sold products**	2000	kg/annum	Gold - currency, jewelery, electrcial components, other etc	