Specialist Climate Change Impact Assessment for Berenice Coal Mine

Prepared by Promethium Carbon for:

Universal Coal Development II (Pty) Ltd, Berenice Coal Mine

01 June 2022

WWW.PROMETHIUM.CO.ZA | TEL: +27 11 706 8185 | FAX: 086 589 3466
THE COURTYARDS, BLOCK 2, 1ST FLOOR, 32 PETER PLACE, BRYANSTON| P.O. BOX 131253, BRYANSTON, 2021
PROMETHIUM CARBON (PTY) LTD | REG NO: 2005/018622/07 | DIRECTORS: RT LOUW, HJ SWANEPOEL

Executive Summary

This report presents the climate change impact assessment conducted by Promethium Carbon (appointed by Universal Coal Development II (Pty) Ltd) for the Berenice Coal Mine located in in the Soutpansberg coalfield. The mine will produce coking coal for export as a primary product and thermal coal for Eskom as a secondary product. The assessment was conducted in accordance with the environmental authorisation process, and in the context of the Thabametsi Case judgement.

Promethium's assessment covered the impact of the proposed project on climate change and the project's resilience to climate change across both the operational phase of the project as well as its lifetime.

The assessment of the project's impact on climate change was based on the project's greenhouse gas (GHG) emissions, as calculated according to SANS 14064:2021 Part 1 and the Regulations and Technical Guidelines published by the Department of Forestry, Fisheries, and the Environment (DFFE).

The assessment of the project's resilience to climate change was guided by the DFFE's Framework for Climate Change Vulnerability Assessments and the Equator Principles. The project's vulnerability was assessed across core operations, value chain (upstream and downstream), and the broader social and environmental context.

This report also addresses possible mitigation and adaptation measures that could be considered by the proposed project developer as recommendations to reduce GHG emissions and improve the project's resilience to climate change.

The impact of the project on climate change was assessed in the context of both GHG emissions from the project, as well as the potential positive impact the project can have through the avoidance of emissions. The project will emit 14 460 ktCO_2e/year during the operational phase and 361 500 ktCO_2e over its lifetime[1].

Coking coal is essential for the manufacturing of steel. The coking coal produced from the Berenice Mine will contribute towards the production of steel globally. The coking coal, and subsequent steel is therefore an enabler for moving the global economy to a 2°C scenario. In the context of the analysis presented above, the project could result in 3 200 tCO_2 abated by the global economy for every tonne of coking coal produced. This equates to 281 GtCO_2 potential abatement over the life of the mine. The life cycle emissions of the coal produced by the Berenice mine is 20 tCO_2e/tonne coal mined. The production of coking coal from the Berenice mine could therefore enable the reduction of 267 tons of CO_2e emission reduced per ton of CO_2e emitted in the life cycle of the coking coal.

1 The emissions for the construction and decommissioning stages are considered insignificant in the context of the overall project and are therefore not calculated in this GHG Inventory.

Climate projections for the location of the Berenice Coal Mine indicate that extreme hot days will increase by between 15 to 56 days for SSP 2 and 17 to 57 days for SSP 5. Annual temperature will increase by at least 2°C to 2.5°C from the baseline period (1961 to 1990). A high to extreme drought risk is also projected for the area, as overall rainfall is predicted to decrease. The increasing variability of rainfall should however also be considered, specifically noting that the Berenice Coal Mine may be exposed to erratic rainfall, periods of drought but then also periods of intense rainfall, which could lead to flash flooding.

Promethium Carbon has not identified any fatal flaws with respect to the CCIA for this project and we do not propose any special conditions with respect to the authorisation of this project. In accordance with our findings, we therefore advise that the proposed Berenice Coal Mine should receive environmental authorization.

Table of Contents

List of Figures

List of Tables

Key Terms and Definitions[2,3]

Adaptive capacity	Adaptive capacity is a set of factors which determine the capacity of a system to generate and implement adaptation measures. These factors relate largely to available resources of human systems and their socio-economic, structural, institutional, and technological characteristics and capacities.
Climate change[4]	The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as: '*a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods*. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition and climate variability attributable to natural causes.
Climate change impacts	The consequences of realised risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather and climate events), exposure, and vulnerability. Impacts generally refer to effects on lives; livelihoods; health and well-being; ecosystems and species; economic, social and cultural assets; services (including ecosystem services); and infrastructure. Impacts may be referred to as consequences or outcomes and can be adverse or beneficial.
Climate change vulnerability	The degree to which a system is susceptible to and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.
Climate resilience	Focuses on the ability to adapt to disturbances and events caused by climate change and investigates future climate-related risks which may pose new challenges for traditional risk management.

2 IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.

3 IPCC, 2022: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. In Press.

4 IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.

Climate variability	Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability).
Exposure	Exposure is directly linked to climate parameters, that is, the character, magnitude, and rate of change and variation in the climate. Typical exposure factors include temperature, precipitation, evapotranspiration, and climatic water balance, as well as extreme events such as heavy rain and meteorological drought. Exposure is the contact between one or more biological, psychosocial, chemical, or physical; stressors, including stressors affected by climate change.
Extreme weather[5]	Is unexpected, unusual, or unforeseen weather and differs significantly to the usual weather pattern, such as droughts, floods, extreme rainfall, and storms.
Greenhouse Gas (GHG)	Greenhouse gasses (GHGs) are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, the atmosphere itself and by clouds. This property causes the greenhouse effect. The Kyoto Protocol deals with the following greenhouses gases, carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), Sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).
Sensitivity	Sensitivity determines the degree to which a system is adversely or beneficially affected by a given climate change exposure and is a function of the natural and socio-economic context of a particular site.
Social vulnerability drivers[6]	Social vulnerability is defined as a dynamic state of societies comprising exposure, sensitivity and adaptive capacity. It is characterised by high levels of dependence on natural resources for livelihoods and economic development, combined with increasing environmental degradation, which can both increase exposure (e.g., wetland destruction) and reduce adaptive capacity (e.g., declining river flows constraining water provision). Examples of social vulnerability drivers include poverty, low awareness and inability to migrate.

5 GIZ. 2014. The vulnerability sourcebook. Gesellschaft für Internationale Zusammenarbeit, Bonn, Germany.

6 Tucker, J., Daoud, M., Oates, N. et al. Reg Environ Change (2015) 15: 783. https://doi.org/10.1007/s10113-014-0741-6.

SSP 2
Shared Socioeconomic Pathway 2

This is the "Middle of the Road" or medium pathway, which extrapolates the past and current global development into the future. In this scenario, there is a certain cooperation between states, but it is barely expanded. Global population growth is moderate, levelling off in the second half of the century. Environmental systems are facing a certain degradation.[7] This scenario is equivalent to RCP 4.5 in the IPCC's Fifth Assessment Report (AR5).

SSP 5
Shared Socioeconomic Pathway 5

This is the "Fossil-fuelled Development" scenario. In the scenario, global markets are increasingly integrated, leading to innovations and technological progress. The social and economic development is based on an intensified exploitation of fossil fuel resources with a high percentage of coal and an energy-intensive lifestyle worldwide. The world economy is growing and local environmental problems such as air pollution are being tackled successfully.[8] This scenario is equivalent to RCP 8.5 in the IPCC's Fifth Assessment Report (AR5).

7 Böttinger, M and D. Kasang. 2021. The SSP Scenarios. Deutsches Klimarechenzentrum, Hamburg, Germany. Available at: https://www.dkrz.de/en/communication/climate-simulations/cmip6-en/the-ssp-scenarios.

8 Böttinger, M and D. Kasang. 2021. The SSP Scenarios. Deutsches Klimarechenzentrum, Hamburg, Germany. Available at: https://www.dkrz.de/en/communication/climate-simulations/cmip6-en/the-ssp-scenarios.

Declaration of Independence

The authors of this report do hereby declare their independence as consultants appointed by Universal Coal to undertake a Climate Change Impact Assessment for the Berenice Coal Mine as part of the environmental authorisation process. Other than fair remuneration for the work performed the specialists have no personal, financial business or other interests in the project activity. The objectivity of the specialists is not compromised by any circumstances and the views expressed within the report are their own.

Robbie Louw

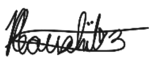
Sarah Goodbrand

Kenneth Slabbert

Shantal Beharie

Shannon Murray

Indiana Mann



Camden Nauschutz

Details of the Specialist Team

Promethium Carbon is a South African climate change and carbon advisory company based in Johannesburg. The company has been active in the climate change and carbon management space since 2004.

Promethium Carbon's climate change impact studies include an estimation of the carbon footprint of the activity or group of activities, as well as the vulnerability of the activity/ies to climate change. Promethium Carbon has calculated greenhouse gas inventories for over 60 entities and is proficient in applying the requirements of ISO/SANS 14064-1 and the Greenhouse Gas Protocol's accounting standards, as well as South Africa's Greenhouse Gas Reporting Guidelines. Promethium Carbon has also assisted around 40 clients develop climate change risk assessments, which includes the compilation of climate change specialist reports. Promethium Carbon's assessments include thorough analysis of historical and projected weather data specific to the region in which the client operates. Promethium Carbon's assessment of vulnerability goes beyond core operations to include impacts within the supply chain and broader network of the Berenice Coal Mine Project

Robbie Louw is the founder and director of Promethium Carbon. He has over 18 years of experience in the climate change industry. Robbie holds both a BCom Honours Degree in Economics as well as a BSc degree in Chemical Engineering. Robbie has significant experience with regards climate change mitigation and adaptation. Robbie's chemical engineering background combined with his extensive experience in climate change has led to him leading several projects related to climate change risk and vulnerability, energy development and developing climate change mitigation and adaptation alternatives. His experience over a period of 35 years covers the chemical, mining, minerals process and energy fields, in which he was, involved in R&D, project, operational and management levels. Robbie is currently a member of The Southern African Institute of Mining and Metallurgy and the Institute of Directors in South Africa (IoDSA). In addition, Robbie is also a member of the Technical Working Group of the Climate Disclosure Standards Board (CDSB). Robbie's experience in climate change includes (but is not limited) to:

- Climate change risk and vulnerability assessments for large mining houses;
- Extensive experience in preparing carbon footprints. The team under his leadership has performed carbon footprint calculations for major international corporations operating complex businesses in multiple jurisdictions and continents;
- Carbon and climate strategy development for major international corporations;
- Climate change impact assessments for various companies and projects;
- Climate change scenario planning and analysis, particularly in terms of the recommendations of the Taskforce on Climate-related Financial Disclosure; and
- In depth understanding of South Africa's climate change regulations and carbon tax requirements.

Sarah Goodbrand is a Senior Climate Change Advisor who holds a Master's in Environmental Sciences specialising in climate change adaptation. Her research investigated ecosystem-based adaptation of urban hydrology to climate change in three South African cities. With nine years of work experience, Sarah has extensive knowledge in climate change mitigation and adaptation within both business and government contexts. Sarah's experience includes GHG inventory calculations, carbon tax liability calculations, climate change impacts assessments, climate change risk and vulnerability assessments and CDP Climate and Water responses. She was instrumental in drafting the first versions of the Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emissions by Industry managed by the Department of Forestry, Fisheries, and the Environment ("DFFE").

Kenneth Slabbert is a Climate Change Advisor who holds a Masters in Mechanical Engineering specialising in energy management. He has four years of experience in climate change mitigation and energy management. Kenneth's experience includes carbon footprint calculations and reporting, carbon tax calculations, climate change impact assessments, energy management, CDP responses and carbon credit project documentation.

Shantal Beharie is a climate change advisor at Promethium. She has eight years of experience in the climate change/sustainability field. She holds a master's degree in environmental studies which focused specifically on historical climate change, as well as an honours degree in geography and a Bachelor's degree in environmental management. Shantal has experience in sustainability (corporate reporting, climate-change scenario analysis, CDP, ESG, TCFD, Science-based targets/net-zero) climate change risk and vulnerability assessments, carbon credit project documentation, climate impact assessments, strategic projects (environmental management frameworks, strategic environmental assessments and compiling state of environment reports), and policy development.

Indiana Mann is a Climate Change Advisor who holds an honours degree in Atmospheric Science. Her postgraduate studies focused on the impact meteorological conditions have on pollen distribution within Cape Town. With her background in Environmental and Geographical Science and Atmospheric Science, Indiana has knowledge in climate modelling, climate change risk and vulnerability assessments and climate change policies. The projects in which she has been active include:

- Climate Change Risk and Vulnerability Assessment;
- Climate Change Impact Assessments;
- The Task Force on Climate-Related Financial Disclosures reports;
- GHG Reporting
- Carbon Footprints and
- Handling of weather data for necessary reports.

Shannon Murray is a climate change advisor who only commenced her employment with Promethium Carbon in October 2021. She completed her BA Degree in Sign Language, as well as her LLB degree through the University of the Witwatersrand. Furthermore, Shannon obtained course certificates through the Wits Mandela Institute in Energy Law, Environmental and Sustainable Development Law, Land and Water Law and International Environmental Law. Shannon was admitted as an attorney in November 2019 and practised as such for a small commercial litigation firm until September 2021. In the short period of time that Shannon has been employed with Promethium Carbon, she has done extensive research in relation to the climate change field and has formed part of various teams within the company. She has gained experience in:

- The legal aspects of carbon credit purchase agreements;
- Developing a socio-economic development project list, with climate change project funding benefits, for a global mining company;
- Developing a climate change target for a listed pharmaceutical company; and
- Performing an eligibility assessment for a carbon credit project, including the legal aspects of the carbon credit transaction.

Camden Nauschutz is an intern climate change advisor at Promethium. He is currently completing his master's degree in environmental science with the Global Change Institute at the University of the Witwatersrand. His master's dissertation is focused on water research, specifically focusing on exploring the drivers of water vulnerability and water scarcity in the City of Johannesburg. Camden's tertiary education covered biogeography, climate change, environmental sustainability, and statistics. He is proficient in R-Studio and GIS. Camden recently completed his first carbon footprint calculation and report for a mining, safety instrumentation company. He also has experience in statistical data analysis of weather data for climate change impact assessments. He is currently assisting companies within the retail sector with calculating their carbon tax liability, as part of the South African Carbon Tax Act.

Report structure and reference in terms of NEMA Regulations (2014), Appendix 6

NEMA Regulations (2014) (as amended) - Appendix 6	Relevant section in report
Details of the specialist who prepared the report	x – xii
The expertise of that person to compile a specialist report including a curriculum vitae	x – xii
A declaration that the person is independent in a form as may be specified by the competent authority	ix
An indication of the scope of, and the purpose for which, the report was prepared	Section 2, sub section 2.2
An indication of the quality and age of base data used for the specialist report	Section 4.1.2
A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 5 and 6
The duration date and season of the site investigation and the relevance of the season to the outcome of the assessment	No site investigation took place as this was a desktop study that relied on requested information
A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used	Section 4
Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure inclusive of a site plan identifying site alternative	Section 7
An identification of any areas to be avoided, including buffers	This is not relevant in terms of the climate change impact assessment. However, this report does make mention of the impacts of climate change on sensitive areas surrounding the Berenice Coal Mine Project

NEMA Regulations (2014) (as amended) - Appendix 6	Relevant section in report
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	This is not relevant in terms of the climate change impact study. However, this report does define the boundaries for which the project's impact on climate change, as well as the project's vulnerability to climate change was determined.
A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 4.2.4
A description of the findings and potential implications of such findings on the impact of the proposed activity or activities	Section 5, 6 and 7
Any mitigation measures for inclusion in the EMPr	Section 8
Any conditions for inclusion in the environmental authorisation	N/A
Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 8
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised and regarding the acceptability of the proposed activity or activities	Section 9
A description of any consultation process that was undertaken during preparing the specialist report	N/A
A summary and copies of any comments received during any consultation process and where applicable all responses thereto	N/A
Any other information requested by the competent authority.	N/A

1 Introduction

Universal Coal Development II (Pty) Ltd have appointed Promethium Carbon to undertake a specialist Climate Change Impact Assessment (CCIA) for the Berenice Coal mine. The proposed mine is situated in the Soutpansberg coalfield 90km southwest of Musina, within the Makhado Local Municipality which falls under the Vhembe District Municipality of the Limpopo Province. The mine will be situated 20km from the Musina-Maputo railway line. The Berenice Project is an opencast mine. The primary product will be soft coking coal and the secondary product will be thermal coal. Key project specifications such as land details, size of acquired land, topography, and boundaries relevant to the Berenice Project are presented in Table 1.

Table 1: Project Details for the Berenice Project.

Access point		Description
Location and Land Details	Project Area	~50km by road from Alldays and about 30km by road from Waterpoort
	Road access	All gravel road branching off from the R584 (between Alldays and Waterpoort)
	Nearest accessible town	Makhado (Louis Trichardt)- about 80km by road to the southeast
	Nearest accessible railway siding	Waterpoort~80km southeast
Extent of Land acquired	7,761,095 ha	

The Berenice Project is in an area which is relatively flat lying with the incision of the Brak River Valley towards the north of the area. It lies at a surface elevation of 690 metres to 735 m above sea level. There are no surrounding human settlements situated within the planned opencast mining area, and the current land-use is game farming (Figure 1).

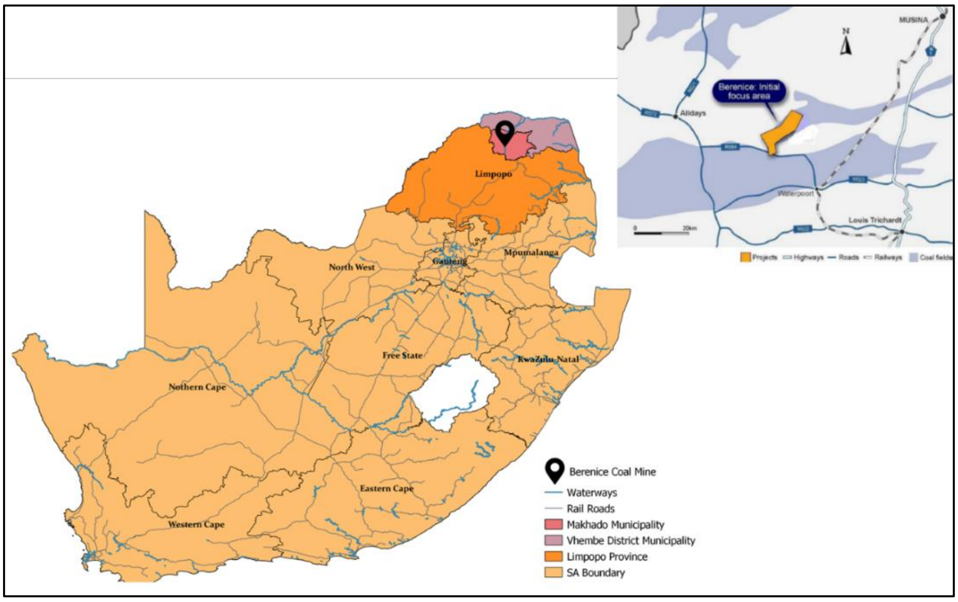


Figure 1: Locality map for the Berenice Project.

2 Background to Climate Change Impact Assessments

The analysis presented in this report is aligned with the principles of the National Environmental Management Act, 1998 (Act No 107 of 1998) and the National Water Act, 1998 (Act No 36 of 1998). This report will inform and assist Universal Coal in developing a climate change strategy for the Berenice Coal Mine Project, which is aligned to the company's environmental management goals. In this context, the impacts of the Project on climate change and the climate change impacts on the Project must therefore be considered.

2.1 The Legal Precedence for Climate Change Impact Assessments in South Africa

2.1.1 Thabametsi Case

The Thabametsi case judgment[9] set the legal precedent for South African CCIA, which has made provision for the inclusion of climate change in the specialist assessments. The environmental authorisation of the proposed Thabametsi coal-fired power station was appealed by Earthlife Africa on the basis that the Chief Director of the Department of Environmental Affairs[10], who initially granted Thabametsi an environmental authorisation, had failed to consider the climate change impacts of the power station. Earthlife Africa (Applicant) maintained that the Minister for Environment, Forestry and Fisheries (now the Department of Forestry, Fisheries, and the Environment "DFFE") was obliged to consider the climate change impacts before granting an environmental authorisation and that it failed to do so[11].

The court found that:

"[…] the legislative and policy scheme and framework overwhelming support the conclusion that an assessment of climate change impacts and mitigating measures will be relevant factors in the environmental authorisation process, and that consideration of such will best be accomplished by means of a professionally researched climate change impact report."[12]

Before the legal precedent set by the Thabametsi case, there was no express provision that stipulated that climate change is a relevant factor to be considered as part of an EIA in South Africa. For this reason - and given the lack of domestic guidelines to assess the climate change impacts of a specific activity - it was necessary to not only consider the principles of the National

---

9 Earthlife Africa Johannesburg v Minister of Environmental Affairs and Others (65662/16) [2017] ZAGPPHC 58; [2017] 2 All SA 519 (GP) (8 March 2017) (saflii.org)

10 Following the announcement of the sixth administration in 2019, the forestry and fisheries functions were amalgamated into the Department of Environmental Affairs, which became known as the Department of Environment, Forestry and Fisheries (DEFF). On 1 April 2021, the DEFF was renamed to the Department of Forestry, Fisheries and the Environment (DFFE).

11 Despite the court victory in March 2017, after reconsideration of the climate change impacts of the plant, the Minister again upheld Thabametsi's environmental authorisation, on the basis that the 2010 Integrated Resource Plan for Electricity (IRP) called for new coal-fired power capacity and had already assessed climate impacts. However, due to its large environmental footprint, funding for the project was pulled and the court ordered that the environmental authorisation be set aside on 19 November 2020.

12 *Ibid*, See par 91 of the Judgement.

Environmental Management Act (NEMA), but to also consider international best practice and international laws which inform CCIAs.

2.1.2 Constitutional Court's Decision to Dismiss New Coal Mining Operations – Uthaka Energy

In November 2021, the Constitutional Court dismissed an application by Uthaka Energy (Pty) Ltd for leave to appeal an interdict that was granted in the Pretoria High Court in March the same year.

The company was interdicted from starting any mining activities and operations at its proposed coal mine. The Constitutional Court's decision to pause the development of new coal mining operations was in part based on the fact that the impacts coal mining has on Strategic Water Source Areas[13] and on global warming, is irrefutable, the impacts must be considered, and ultimately, Africa (in this case South Africa) needs to build resilience to climate change, and not add to it.

The circumstances of the Uthaka Project are similar to those of the Berenice Coal Mine with regards to coal mining. The case is worth mentioning in terms of what a Court considers as the necessary procedure for implementation of a project that has adverse effects on the environment, and subsequently, the impacts of climate change.

The interdict that was granted in the Pretoria High Court in March 2021, confirms the fundamental importance of fair and transparent decision making, which was not taken by the then Ministers in granting the environmental authorisations. Therefore, in the context of the Berenice Coal Mine Project, an open and transparent process must be followed when obtaining the necessary environmental authorisations, failing which, the consequences may be dire in terms of being interdicted from commencing the project activities.

2.1.3 Purpose of the Climate Change Impact Assessment

The EIA process was completed for the Berenice Mine, and the EA was issued on 6 March 2020.. The project EA was first appealed on 26 June 2020, with a second appeal on 13 July 2020, and a third appeal on 14 September 2020. As such, this CCIA was prepared, considering the three appeals regarding inadequate specialist reports and climate change impacts.

The process is in accordance with the requirements of the 2014 EIA regulations promulgated in terms of the National Environmental Management Act (NEMA: Act No 107 of 1998). As part of the specialist requirement under NEMA regulations 12(1) for the EIA, Promethium Carbon will

---

13 In 2018, the Water Research Commission (WRC) updated the definition of "Strategic Water Source Areas" (SWSA), to include groundwater, and now defines SWSA's as:
"*areas of land that either:*
(a) supply a disproportionate (i.e., relatively large) quantity of mean annual surface water runoff in relation to their size and so are considered nationally important; or
(b) have high groundwater recharge and where the groundwater forms a nationally important resource; or
(c) areas that meet both criteria (a) and (b)".
In short, SWSA's are considered to be of national importance for the water security of South Africa.

undertake a CCIA for the Berenice Project. The analysis presented in this report is aligned with the principles of the *National Environmental Management Act* (NEMA), 1998 (Act No 107 of 1998).

Climate change is generally considered to be covered within existing environmental law frameworks, since climate change impacts the environment and societies living in certain environments. South Africa's overarching environmental law framework is founded in NEMA. The *Environmental Impact Assessment (EIA) Regulations of 2017* (which were promulgated under NEMA), were predominantly drafted to govern activities which have an impact on the environment within the Republic of South Africa. Therefore, applying NEMA's principles to a global phenomenon, such as climate change, presents a challenge.

The Berenice project, during the operational phase will release GHG emissions which will contribute towards climate change. The Berenice project will also contribute towards the national GHG emissions inventory. Therefore, the purpose of the CCIA would be to quantify and incorporate impact of climate change during the EIA phase of the project.

2.2 Scope of the Climate Change Impact Assessment

This CCIA includes the following aspects and is based on the guidance from the Thabametsi judgement. Based on the scoping report, the issues relating to climate change need to be further investigated as part of the EIA phase.

- The **impact of the Project** on climate change:
    - A GHG inventory for the operational phase of the project, as well as its lifetime;
    - An analysis of the GHG inventory regarding the impact of the GHG emissions of the project on climate change;
    - A description of the existing climate conditions of the local area;
    - An impact assessment of the project, which includes the cumulative impacts of climate change in relation to the project;
    - Mitigation and adaptation measures to minimise the impacts of the proposed project on climate change.

- The **impacts of climate change** on the project:
    - Impacts on core operations – likely exposure to climate changes, sensitivity to such and vulnerability assessment;
    - Impacts on upstream value chain;
    - Assessment of climate change related impacts on the local natural environment, surrounding communities, local ambient air quality, and human health, and any associated implications for the project.;
    - Assessment of potential climate change adaptations

- The **resilience of the project** in terms of climate change:

- An analysis of the climate change impacts for the region in which the project will be located;
- The processes and associated infrastructure of the proposed project that could be affected by climate change, and the potential magnitude of the impacts; and
- Mitigation and adaptation measures to minimise the impacts of climate change on the proposed project.

The analysis of climate change risks includes both physical and transitional risks. The scope of inclusion of these risks are set out in the table below:

Table 2: Coverage of risks in the CCIA.

	Risk	Included/excluded
Physical risks	Risk such as extreme weather events, storms, droughts, etc.	Included in the CCIA as it can significantly impact on the resilience of the project to climate change in the core operations, value chain, natural environment and social environment.
Transitional risks	Risks such as regulation, carbon pricing, and stranded asset risks	These risks are excluded from the CCIA as they represent commercial risks to the owner of the project rather than environmental and societal risks that are governed in the context of NEMA

2.3 Description of Project Activities and Associated Infrastructure

A prospecting right has been granted to the Berenice project. The mining reserves will be mined using truck and shovel opencast methods due to shallow reserves. The topsoil will be removed and stored, softs will be removed and stored at designated mine stockpiles. Drilling and blasting will be undertaken for hard materials. Following the blasting process, material will be dozed into the void following a coaling operation. Rehabilitation will form an integral part of the mining process. The subsections below describe the associated infrastructure and water requirements for the project.

The mine will supply a high volatile soft coking coal product for export and thermal coal to Eskom[14]. The coal will be beneficiated through a double-stage dense medium washing plant. about 10 million tonnes per annum. The processing section of the plant will be split into two identical modules due to the amount of material that needs to be treated.

2.3.1 Project Infrastructure

The relevant infrastructure for the project is described below:

Table 3: Road Infrastructure

[14] The gross calorific value (CV) range required by Eskom is 20 – 24 MJ/kg. The Berenice Mine plans to produce product with a CV of 22.3 MJ/kg.

Roads
Access roads A new main road from the existing R523 will be constructed. The road will be 7.4m wide, surfaced road with stormwater earth channels and mitre drains to protect the road infrastructure from flood risks and damage. The road intersections will be designed properly to provide safe entry and exit into the mine. *Internal Mining roads* The internal roads will be 6m wide with semi mountable kerbs and non-mountable kerbs on both sides of the road as required. The internal roads will be equipped with the required stormwater systems to prevent flooding. *Haul roads* There will be dedicated haul roads for the rigid dump trucks. These will be 32m wide with safety beams on either side. The road pavement structure and design will be designed in a manner that accommodates the largest vehicle to be used in operations. The dust will be managed by applying road binders and regular watering with water tankers. The design will also include stormwater drainage and culverts to protect the road structure and divert water to natural water courses. *Pit bound and light delivery vehicle roads* A 6m wide gravel roadway between the mine vehicle roadway and the haul road will be constructed. The dust will be managed by applying road binders and regular watering with water tankers.
Contractors lay down area and site establishment
Contractors will be provided with a laydown area, water and electrical connections. The provision of utility services, offices and warehousing will be temporary and supplied by each individual contractor.
Rail Line Extension
The rail line is proposed as an alternative to transport the coal from the Berenice Mine to Waterpoort Station. However, this option is yet to be explored in terms of its feasibility and will be investigated further. Should it be an option, a separate EIA will be conducted.

2.3.2 Water Supply

The Berenice Project requires 3 mega litres/day to ensure that the mining operations remain effective and efficient. The table below indicates the water supply requirements for the project.

Table 4: Water Supply Infrastructure.

Water Requirements for Staff
The water requirement for staff is estimated to be 200 litres per person per day. The capacity for the water supply needs to be 42.6 kilolitres per day. Boreholes will be established to supply water to meet staff requirements. As part of this intervention a small water treatment plant will be built at the mine to produce potable water from borehole water.
Industrial water requirements
Bulk water supply will potentially be one of the biggest non-commercial influences on the viability of the Berenice Project. No bulk water supply currently exists within the vicinity. The regional district municipalities do not have provision for future bulk water-supply development. The project will therefore rely on the extraction of ground water from well fields established in the area. This appears to be the most viable option for the Berenice Project.

Water Consumption The washing plant freshwater consumption, required as make-up water is estimated to be between 3000 - 4500 cubic metres per day. The plant will be equipped with a filter press and thickener to clarify the plant for re-cycle and reuse. The effluent and wastewater from the plant will be pumped to the process water tank for re-use.
Surface Run-off Water
Run-off water will be collected and stored in holding ponds which will be located near pits. The water will be routed to the holding area and collected water will be used for the mining and treatment process. All mine-water will be stored in a high-density polyethylene-lined pollution control dam and re-used in the beneficiation plant as well as for dust-control purposes on the haul road.
Water treatment Plant
The location of the water treatment plant has not been determined at this point. The consideration for a water treatment will only be required towards the end of the life of mine.

2.3.3 Surface Infrastructure

The table below indicates the surface infrastructure that will be built as part of the proposed mine.

Table 5: Surface Infrastructure.

Brake test ramp
The brake test ramp is included to test the braking capabilities of vehicles into the pit. A dedicated parking will allow for rigid dump trucks with safety berms and the vehicles will be approached from the rear parking areas.
Stormwater management
Stormwater infrastructure (drains and deflection beams) will be constructed on site. Clean and dirty water systems will be separated and where feasible the storm water runoff will be routed around the site and away from potential contamination areas. Clean water sources and drains will be redirected towards natural water courses in the area. Contaminated areas such as workshops, fuel storage bays, conveyor routes, discard dumps, wash down areas, stockpiles and tip areas will have a network of concrete lined drains and pipe culverts which will gravitate towards a pollution control dam (PCD). The PCD will accommodate a 1:100-year storm period. It will be designed to withstand extremes rainfall ad storm events.

2.3.4 Sewerage Treatment

Sewerage treatment will be carried out to maximise water recovery. The sewerage from the mining area will be collected in a sewerage network and will flow into the treatment plant. The sewer network will comprise of 110 mm and 160 mm diameter pipes with manholes spaced at maximum of 100 m intervals on straight sections as well as at all bends and junctions. The sewerage treatment plant will comprise of the following:

- Average Daily Flow: 60m^3 per day;
- Peak Factor: 3;

- Influent: Domestic raw sewerage;
- Treated Effluent: Department of Water and Sanitation (DWS); and
- Storm water infiltration: 15% of total daily flow.

2.3.5 Substations

Bulk power will be supplied to the project via two powerlines to the indoor substation. There is no suitable Eskom infrastructure within the vicinity of the site, the closest town to draw electricity from is in Louis Trichardt (Makhado). There is an option to tie into the existing national grid at 132 kilovolts (kV) or 88 kV high voltage level at the existing Eskom substations.

3 Climate Change Context

The climate change context of this project considers the projected climatic changes in terms of the GHG emissions, as well as global carbon budgets.

3.1 Projected Climatic Changes

GHG emissions from all sources accumulate in the atmosphere and contribute to global climate change. One of the main GHGs is carbon dioxide (CO_2). Like all GHGs, CO_2 contributes to climate change by trapping heat in the atmosphere. The greater the concentration of GHGs, the greater the warming effect.

As a result of the continuous emissions of GHGs, it is highly likely that a warming of global average temperatures will exceed 1.5°C above pre-industrial levels by 2100. Heavy precipitation events will become more intense and frequent. The irreversible melting of the ice sheets will be initiated, resulting in harmful sea level rise. Furthermore, tropical cyclones and wind speeds are likely to increase globally. These climatic changes increase the possibility of irreversible changes in the way the planet, and in turn, human societies and economies will function.

Based on the most recent climate change projections for the Southern African region[15], South Africa is warming at twice the global rate of temperature increase. Temperatures could from 3°C, up to more than 7°C (Figure 2). Extreme weather events, such as droughts, storms and floods are likely to become more intense, frequent, and unpredictable. Water stress will increase. The western parts of the country are projected to become hotter and drier, and the eastern parts wetter.'[16]

---

15 Engelbrecht, F., Le Roux, A., Arnold, K. & Malherbe, J. 2019. Green Book. Detailed projections of future climate change over South Africa. Pretoria: CSIR. Available at: https://pta-gis-2-web1.csir.co.za/portal/apps/GBCascade/index.html?appid=b161b2f892194ed5938374fe2192e537.

16 Republic of South Africa. 2021. First Nationally Determined Contribution under the Paris Agreement (Updated September 2021). Republic of South Africa, Pretoria.

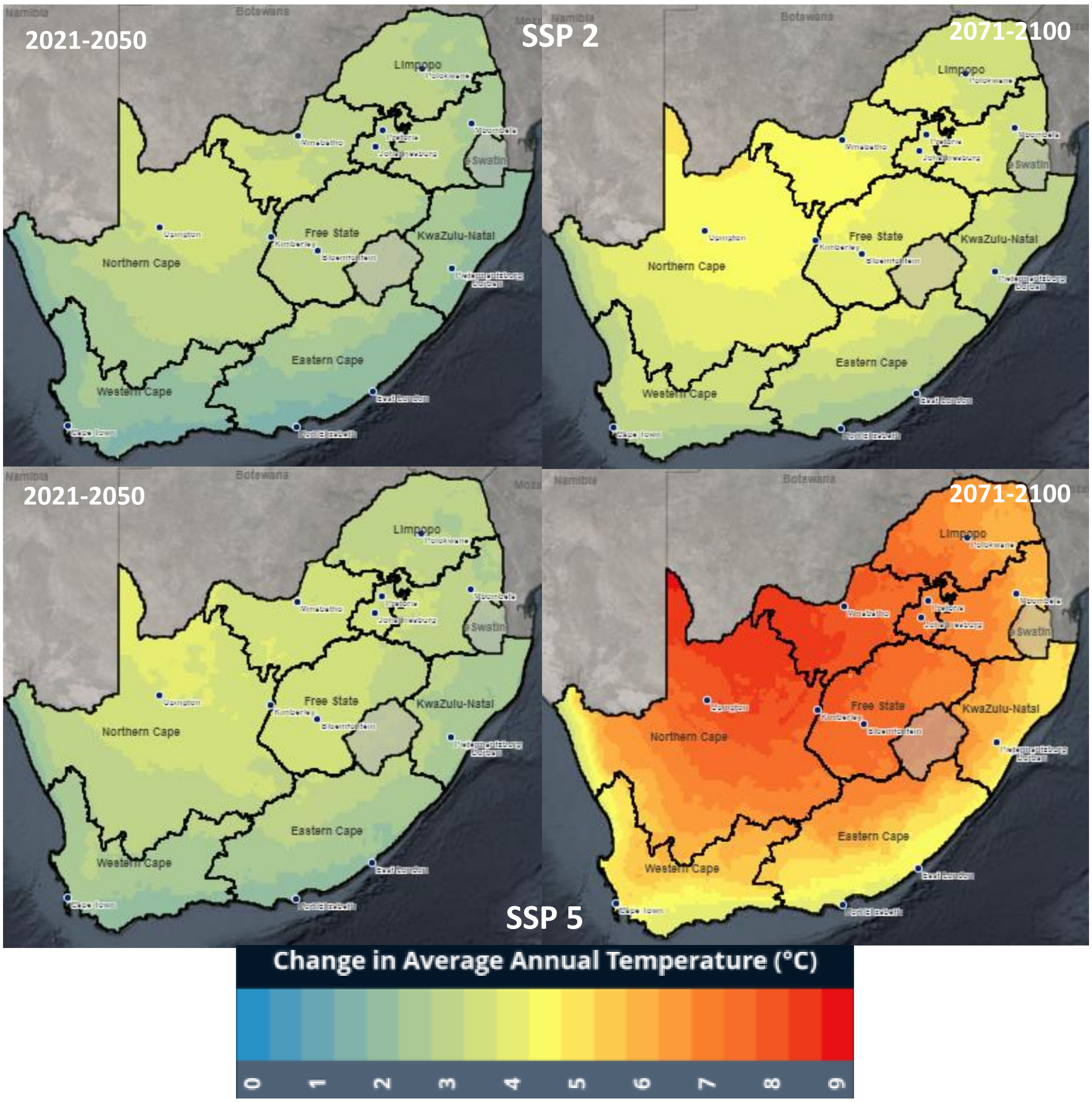


Figure 2: Projected change in average annual temperatures (90th percentile) for the Shared Socio-economic Pathway (SSP) 2 (previously RCP 4.5) and Shared Socio-economic Pathway 5 (previously RCP 8.5)

To collectively prevent changes in the natural system to the extent that they can no longer support socio-economic activities, as we know them, we need to understand how much more GHGs the global community can afford to emit. This can be done using global carbon budgets.

3.2 Carbon Budgets

A carbon budget can be defined as an allocation of a quantity of GHGs that can be emitted over a specified period. The guiding principle could be limiting global warming to a certain level or meeting a regulatory requirement or a similar limit.

This specialist CCIA is a legal requirement for environmental authorisation of the proposed Berenice Mine. Thus, the guiding principle considered for a carbon budget will be the emission limits set out in South Africa's Nationally Determined Contribution[17] (NDC), updated in 2021.

[17] Republic of South Africa (2021). *South Africa – First Nationally Determined Contribution Under the Paris Agreement*.

Table 6 shows the target emissions for the low and high emissions scenarios, as given in the 2021 NDC, with the aim of reaching net zero by 2050.

Table 6: Targeted annual emissions for South Africa, according to the 2021 NDC.

	2020	2025	2030	2050	Cumulative Emissions
Low Emission Scenario	398 $MtCO_2e/y$	398 $MtCO_2e/y$	350 $MtCO_2e/y$	0 $MtCO_2e/y$	7 758 $MtCO_2e$
High Emission Scenario	510 $MtCO_2e/y$	510 $MtCO_2e/y$	420 $MtCO_2e/y$	0 $MtCO_2e/y$	9 585 $MtCO_2e$

Thus, the cumulative emissions from 2020 to 2050 across the low and high emissions scenarios are 7 758 MtCO2e and 9 585 MtCO2e, respectively. These figures are the low and high emission carbon budgets for South Africa. The low emission carbon budget will be used as a conservative estimate of a carbon budget against which to measure the impact of the proposed Berenice Mine.

4 Approach and Methodology

4.1 Project Impact on Climate Change

The Berenice Mine's impact on climate change will be determined by developing a project GHG inventory for the project across its lifetime. This process is described further below.

4.1.1 GHG Inventory

The basic premise of calculating a GHG inventory is to identify the relevant activities, the relevant emission sources and to quantify the emissions associated with these activities and sources. The emissions are quantified using the following generic equation.

$$Emissions = Activity\ data \times Emission\ Factor$$

The following section provides more details regarding this process. All equations provided in Section 4.1.1.2 are derivations of this fundamental equation for determining emissions from an activity.

4.1.1.1 Standards used

At the time of writing of this report, South African laws (most are considered under the umbrella of the National Environmental Management Act - or NEMA), do not yet provide adequate guidelines for CCIAs[18]. Thus, this report also makes use of globally accepted international best practice and is guided by the Thabametsi judgement.

[18] South Africa's Department of Forestry Fisheries and the Environment is in the process of providing further guidelines for Climate Change Impact Assessments. However, these guidelines are only a draft and have not yet been published.

The GHG inventory for the proposed Berenice Mine has been guided by the following reference documents for this CCIA:

- *SANS 14064:2021 Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals* [19];
- The Greenhouse Gas Protocol's *A Corporate Accounting and Reporting Standard (Revised Edition)*[20];
- The Department of Environmental Affairs' *Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emissions by Industry*[21];
- The Department of Forestry, Fisheries and the Environment's *Technical Guidelines for the Validation and Verification of Greenhouse Gas Emissions*[22];
- The 2006 Intergovernmental Panel on Climate Change (IPCC) *Guidelines for National Greenhouse Gas Inventories*[23]; and
- The Intergovernmental Panel on Climate Change (IPCC) *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, Chapter 4*[24].

The main guiding document used, in the calculation of the impact of the project on climate change, is the *SANS 14064:2021 Part 1*. This document sets out principles summarised in Table 7, that guide the GHG inventory development process. It requires that emissions be categorised into the following groups:

- **Category 1** – Direct GHG emissions and removals;
- **Category 2** – Indirect GHG emissions from imported energy;
- **Category 3-6** – All other indirect GHG emissions

Table 7: ISO/SANS 14064-1 principles for carbon footprints

Relevance	Selecting all the greenhouse gas sources, sinks, reservoirs, data and methodologies that are appropriate.
Completeness	Including all the greenhouse gas emissions and removals relevant to the proposed project.
Consistency	Enable meaningful comparisons to be made with other greenhouse gas related information.
Accuracy	Reducing bias and uncertainties as far as is practical.
Transparency	Disclosing sufficient and appropriate greenhouse gas related information to allow intended users to make decisions with reasonable confidence.

[19] Standards South Africa, 2021, *SANS 14064-1:2021 Greenhouse Gases Part 1: Specification with guidance at the organisational level for the quantification and reporting of greenhouse gas emissions and removals*, Pretoria.
[20] Greenhouse Gas Protocol, 2015, *A Corporate Accounting and Reporting Standard: Revised Edition*.
[21] Department of Environmental Affairs, 2016, *Technical Guidelines for Monitoring, Reporting and Verification of GHG Emissions by Industry*.
[22] The Department of Forestry, Fisheries and the Environment ,2021, *Technical Guidelines for the Validation and Verification of Greenhouse Gas Emissions*
[23] IPCC, 2006. *IPCC Guidelines for National Greenhouse Gas Inventories*, [Online] Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/ [Accessed on 05/04/2020].
[24] IPCC, 2019. *Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.*

The calculation of the GHG inventory for the proposed Berenice Mine, follows the general steps stipulated here:

- Boundaries of the analysis are set;
- GHG sources/sinks inside the boundary are identified;
- The significance of each of the emission sources is determined;
- Quantification method is established; and
- GHG emissions inventory is calculated.

Note that traditionally, GHG reporting has been done using the 2006 version of SANS14064 - 1 in combination with the Greenhouse Gas Protocol's *A Corporate Accounting and Reporting Standard*, which classified emission in 3 emission scopes. The relationship between the traditional emission scopes and the latest version of the SANS14064 - 1 standard is shown in the Table 8 below:

Table 8: GHG reporting for both standards ISO 14064:2021 and ISO 14064:2006.

SANS 14064:2021		ISO 14064:2006	
Category	Description	Category	**Description**
1	Direct GHG emissions and removals	Scope 1	
2	Indirect GHG emissions from imported energy	Scope 2	Energy indirect emissions
		Scope 3 Category 3	Fuel- And Energy-Related Activities
3	Indirect GHG emissions from transportation	Scope 3 Category 3	Fuel- And Energy-Related Activities[25]
		Scope 3 Category 4	Upstream Transportation and Distribution
		Scope 3 Category 6	Business Travel
		Scope 3 Category 7	Employee Commuting
		Scope 3 Category 9	Downstream Transportation and Distribution
4	Indirect GHG emissions from products used by organization	Scope 3 Category 1	Purchased Goods and Services
		Scope 3 Category 2	Capital Goods
5	Indirect GHG emissions associated with the use of products from the organization	Scope 3 Category 10	Processing of Sold Products
		Scope 3 Category 11	Use of Sold Products
		Scope 3 Category 12	End-Of-Life Treatment of Sold Products
6	Indirect GHG emissions from other sources	Scope 3 Category 5	Waste Generated in Operations

[25] Note that the activities that used to be included under Scope 3 Category 3 have been split into Category 2 and Category 3 of the new standard.

SANS 14064:2021		ISO 14064:2006	
Category	Description	Category	**Description**
		Scope 3 Category 8	Upstream Leased Assets
		Scope 3 Category 13	Downstream Leased Assets
		Scope 3 Category 14	Franchises
		Scope 3 Category 15	Investments

4.1.1.2 Boundary setting for Inclusion of Indirect Emissions

The boundary of the GHG Inventory for the Berenice Mine is established in accordance with SANS 14064-1:2021 standard. The standard outlines the process as identifying emission sources at the operation and its value chain. All direct emission sources are included in the boundary while indirect emission sources are identified through a significance assessment.

The direct emission sources included in the boundary for the operational phase are the combustion of fuel in stationary and mobile mining equipment.

The indirect emission sources are assessed based on the following significance criteria.

- **Magnitude**: Activities contributing more than 30 0000 tCO_2e/y (1% of the Low impact threshold discussed in Section 4.1.4) shall be included in the assessment.
- **Level of influence**: Activities where the project owner could engage with the supplier to reduce upstream emissions, or where the company can choose a supplier based on their emissions, shall be included.
- **Risk or opportunity**: Activities that significantly contribute to the organization's exposure to climate-elated risks or opportunities shall be included.
- **Sector-specific guidance**: The GHG emissions deemed as significant by the business sector, as provided by sector-specific guidance[26].
- **Outsourcing**: Not applicable, as no core business activities are outsourced within the context of this specialist climate change impact assessment.
- **Employee engagement**: Activities that could motivate employees to significantly reduce energy use or that federate team spirit around climate change shall be included.

The indirect emission sources relevant to the Berenice Mine are assessed in Table 9 below. Where an emission source has been classified as Medium or High, they have been included the GHG inventory boundary.

[26] Not yet available.

The magnitude criteria are defined as High if it is greater than 50% of the overall inventory, Medium if it is between 5% and 50% and Low if it is less than 5%.

Table 9: Indirect emission significance assessment

Emission source	Significance criteria						Inclusion in the GHG inventory boundary
	Magnitude	Level of influence	Risk or opportunity	Sector-specific guidance	Outsourcing	Employee engagement	
Production of purchased electricity	**Low** – forms less than 1% of the overall inventory	**High** – can influence these emissions by generating own renewables up to 100MW or PPA's with renewable independent power producers	**High** - risk of energy security and supply disruptions from climate change related events	N/A	N/A	**Low** – some change in these emissions could come from engaging with employees on responsible energy consumption	Include based on Influence and Risk
Production of fuel used in operation	**Low** – forms less than 1% of the overall inventory	**High** – can switch suppliers of fuels to lower emission sources	**High** - risk of energy security and supply disruptions from climate change related events	N/A	N/A	**Low** – some change in these emissions could come from engaging with employees on responsible energy consumption	Include based on Influence and Risk
Employee commuting	**Low** – forms less than 1% of the overall inventory	**Medium** – can influence emissions through employee engagement programmes	**Low** - there is some risk in disruptions to the production of cement due to climate change related events	N/A	N/A	**High** – these emissions could be changed through ride sharing, public transport and other employee engagement programmes	Include based on Employee Engagement
Downstream transport of product	**Low** – forms less than 1% of the overall inventory	**Medium** – influence to switch transport companies. Can also switch to shipping to local markets thus reducing the distance required.	**Medium** – disruption to transportation due to climate events such as extreme weather	N/A	N/A	N/A	Include based on Influence

Emission source	Significance criteria						Inclusion in the GHG inventory boundary
	Magnitude	Level of influence	Risk or opportunity	Sector-specific guidance	Outsourcing	Employee engagement	
Processing of sold product – Coking coal	**High** – forms 45% of the overall inventory which is above the 50% threshold	**Low** – Universal coal has no control over the emissions associated with the use of their product. The use of the coking coal will occur in global steel mills outside of the operational control of Universal Coal. Furthermore, the global steel demand will increase as climate change ambitions are increased.	**Medium** – There is an opportunity for reductions in global emissions due to the potential contribution of steel to mitigation efforts.	N/A	N/A	N/A	Exclude based on Influence
Processing of sold product – Thermal coal	**High** – forms 953 of the overall inventory which is above the 50% threshold	**Low** – Universal coal has no control over the emissions associated with the use of their product. The amount of thermal coal required in South Africa is determined by the IRP and is not mine dependent.	**Low** – the use of coal in power generation is fixed in the IRP.	N/A	N/A	N/A	Exclude based on Influence

4.1.1.3 GHG Inventory Development

The direct, upstream, and downstream emissions for operational stages of the Berenice Mine are calculated based on the procedures below considering the boundary above. The emissions for the construction and decommissioning stages are considered insignificant in the context of the overall project and are therefore not calculated in this GHG Inventory.

The direct emissions relate to onsite emissions during operation (such as combustion of fuels). The upstream emissions relate to the sourcing of materials consumed during operation (such as material manufacture and transport emissions). The downstream emissions relate to the end of life of materials and the use of sold products (such as waste management activities and steel manufacture).

These emissions are given in CO_2 equivalents (CO_2e). A CO_2 equivalent is when the emissions of other GHGs are equated to an equivalent amount of CO_2 using the 100-year global warming potential (GWP) of that gas. The GWP of any GHG is the amount of heat absorbed, per mass unit of a GHG, divided by the amount of heat an equivalent mass of CO_2 would absorb over the specified period.

The operation-related emissions are calculated using the equation as described in the beginning of 4.1.1. The generic *Activity Data, Emission factor and Emission* terms are replaced with specific parameters to describe the emissions under consideration.

During operation, the Category 1 emissions are from stationary and mobile combustion of diesel. These emissions can be calculated as followed:

$$Cat1_D = (Diesel \times EF_{SD})$$

Where:

- $Cat1_D$ represents the direct emissions during the operation phase of the Berenice Mne, measured in tCO_2e/year;
- $Diesel$ represents the total combustion of diesel during the operation phase of the Berenice mine, measured in litres/year;
- EF_{SD} represents the emission factor of stationary combustion of diesel, measured in tCO_2e/l;

The Category 2 emissions during the operation were calculated as following:

$$Cat2_{Elec} = (\text{Electricity}_x \times EF_{Elect})$$

Where:

- $Cat2_{Elec}$ represents the Category 2 emissions during the operation phase of the Berenice Mine, measured in tCO_2e/year;

- Elect_x represents the electricity consumed in year *x* at the Berenice Mine, measured in MWh/year; and
- EF_{Elect} represents the grid emission factor for electricity, measured in tCO_2e/MWh.

The indirect emissions (Category 3 – 6) will account for the purchased goods and services, fuel and energy related activities, upstream and downstream transportation and distribution, use of sold products and waste generated. The main calculation that was used for these emissions is:

$$Scope3_{IDE} = (Act_x \times EF_{Act})$$

Where:

- $Scope3_{IDE}$ represents the total indirect emissions during the operation phase of the Berenice Coal Mine, measured in tCO_2e/year;
- x represents the phase that is being account for. i.e., operational phase;
- Act_x represents the activity data occurring at the Berenice Mine for a specific phase x, measured in Unit of Measurement/year. The Unit of Measurement depends on the activity for example tonnes of purchased material or distance transported; and
- EF_{Act} represents the emission factor of that activity data, measured according to the activity measurement.

4.1.2 Data used

The two main data requirements to calculate the GHG emissions for this project are (i) activity data and (ii) emission factors. The combination of these two data sets results in the development of a GHG inventory. The sources of these data sets vary and are discussed in further detail in the sections below.

4.1.2.1 Activity Data

The activity data was collected from the project developer. Where the project developer could not provide data, activity data was estimated using conservative assumptions, which were agreed upon with the client. Table 7 summarises the activity data used.

Table 10: Activity data used to calculate the GHG inventory.

Construction Phase	Quantity	Unit	Data Source
Based on previous CCIAs conducted by Promethium, the construction emissions are assumed to be negligible for this proposed mine.			
Operation Phase	**Quantity**	**Unit**	**Data Source**
Electricity purchased – mine	37 500 000	Rand/year	Mine Works Plan
Electricity purchased – processing	80 838 755	Rand/year	Mine Works Plan
Diesel purchased – mine	315 000 000	Rand/year	Mine Works Plan
Diesel purchased – processing	61 146 557	Rand/year	Mine Works Plan
Run of mine coal – thermal	3 383 345	Tonnes/year	Mine Works Plan
Run of mine coal – coking	2 098 569	Tonnes/year	Mine Works Plan
Mine employees	81	People	Mine Works Plan

4.1.2.2 Emission Factors

The emission and conversion factors applied in the calculation of the proposed Berenice Mine's GHG inventory, are aligned with the following principles:

- derived from a recognised origin;
- appropriate for the GHG source concerned;
- current at the time of quantification;
- take account of quantification uncertainty and are calculated in a manner intended to yield accurate and reproducible results; and
- consistent with the intended use of the carbon footprint.

The emission factors used were taken from a wide variety of sources. Specifically for the emissions from the combustion of fuels, South Africa's *Technical Guidelines on the Monitoring, Reporting and Verification of GHG emissions by Industry* were used. Table 8 provides the emissions factors used and their respective sources.

Table 11: Emission and conversion factors used for GHG inventory.

Category 1 Emissions	Value	Reference
Diesel	0.0028 tCO_2e/l	SA Technical Guidelines[27]
Category 2 Emissions	**Value**	**Reference**
Purchased Electricity	1.08 tCO2e/MWh	Calculated from Eskom's FY21 Annual Report
Production of diesel consumed	0.6287 $kgCO_2e/L$	DEFRA 2021

[27] Department of Environmental Affairs, 2017, *Technical Guidelines for Monitoring Reporting and Verification of Greenhouse Gas Emissions by Industry.*

Category 3 Emissions	Value	Reference
Heavy Goods Vehicle	0.86407 kgCO_2e/km	DEFRA 2021
Cargo Ship	0.003539 kgCO_2e/tonne.km	DEFRA 2021
Private car	0.0002232 tCO_2e/passenger.km	DEFRA 2021
Taxi	0.0000242 tCO_2e/passenger.km	Toyota Quantum specifications
Private car	22% of mine employees	Assumed that top, senior and mid management commute by private vehicle
Taxi	78% of mine employees	Assumed that the remainder of mine employees commute by taxi
Product transport distance	310 km	Road distance from Waterpoort to Medupi power station. Assumed that all thermal coal is used by Medupi
Sea distance to India	8 666 km	Distance to India. Assumed that coking coal is used in steel production in Asia and the Middle East
Category 4 Emissions	**Value**	**Reference**
Coal combustion	2.3101 tCO_2e/tonne	South African Technical Guidelines
Coking coal use	3.1652 tCO_2e/tonne	DEFRA 2021

4.1.3 Environmental Impacts of GHG Emissions

An environmental impact assessment requires that local impacts be quantified according to a given set of criteria. These are the **Nature**, the **Extent**, the **Duration**, the **Magnitude**, the **Probability,** and the **Significance** of the impacts. However, climate change is a global phenomenon, meaning these criteria are inadequate to fully quantify the impact. Despite this, these criteria are currently the only criteria available to measure the impact of the project on climate change.

Table 12: Environmental impact assessment criteria

Nature	A description of what causes the effect, what will be affected and how it will be affected. In the case of climate change assessments, the nature of the impact is the contribution of the project to global anthropogenic climate change.

Extent (E)	An indication of whether the impact will be local (limited to the immediate area or site of development), regional, national, or international. A score of between 1 and 5 is assigned as appropriate (with a score of 1 being local (low) and a score of 5 being international (high). In the case of climate change assessments, the extent is always global, and thus a 5 is allocated to all projects that contribute to global anthropogenic climate change.
Duration (D)	An indication of the lifetime of the impact quantified on a scale from 1-5. Impacts with durations that are; very short (0–1 years) are assigned a score of 1, short (2-5 years) are assigned a score of 2, medium-term (5–15 years) are assigned a score of 3, long term (> 15 years) are assigned a score of 4 or permanent are assigned a score of 5. In the case of climate change assessments, the emission of non-renewable based GHGs can be considered permanent emissions. Thus, a 5 is allocated to all projects that contribute to global anthropogenic climate change.
Magnitude (M)	An indication of the consequences of the effect are quantified as follows: • 0 is allocated to projects that do not have GHG emissions; • 2 is allocated to projects with a rating of ***Low***; • 5 is allocated to projects with a rating of ***Medium***; • 7 is allocated to projects with a rating of ***High***; and • 10 is allocated to projects with a rating of ***Very High***. The quantification of the impact rating thresholds is discussed in more detail in Section 4.1.4.
Probability (P)	An indication of the likelihood of the impact actually occurring estimated on a scale of 1–5. A score of 1 implies that the impact is very improbable, 2 are improbable, 3 are probable, 4 are highly probable and 5 are definite with the impact occurring regardless of any prevention measures. The IPCC has reported that it is 95 percent certain that man-made emissions are the main cause of current observed climate change[28]. Thus, a value of 5 is allocated to all projects that contribute to global anthropogenic climate change.
Significance (S)	The significance points are calculated as: S = (E + D + M) x P. A weighting based on a synthesis of the characteristics described above and can be assessed as low (< 30 points), medium (30-60 points) or high (> 60 points).

[28] IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

4.1.4 Determining the Magnitude of the Project Impact on Climate Change

4.1.4.1 Determination of the Low Impact Level for GHG Impact Rating

The DFFE has published the draft *National Guideline for the Consideration of Climate Change Implications in Applications for Environmental Authorisations, Atmospheric emissions Licenses and Waste Management Licenses* in January 2021. One of the guidelines for when a specialist climate change impact assessment is necessary is when the activity breaches one of the thresholds stipulated in the *National Greenhouse Gas Reporting Regulations*. Thus, the low impact level was taken as the combustion of coal at a capacity of 10 $MW_{thermal}$ at a 100% utilisation.

$$Upper\ limit\ \text{Low} = 10\ MW_{thermal} \times \frac{31\ 536\ 000\ s}{year} \times \frac{1\ TJ}{1\ 000\ 000\ MJ} \times EF_{coal}$$

The emission factor for coal is taken as "Other Bituminous Coal" from Table A.1 of the Technical Guidelines[29]. This equates to approximately 30 000 tCO_2e/year. Thus, emissions less than 30 000 tCO_2/y will be considered to have a ***Low*** impact.

4.1.4.2 Determination of the Very High and High Impact Level for GHG Impact Rating

The lower limit for the ***Very High*** impact category was calculated to be the annual emissions of a new coal fire power station. The size of the hypothetical power station was equivalent to the average capacity of the Eskom coal-fired fleet, namely 2 900 MW[30]. The annual emissions were calculated using an efficiency taken from the 2017 EPRI Report[31] for new coal-fired power stations and the current availability of the Eskom fleet. The annual emissions calculated, and thus the limit between the ***High*** and ***Very High*** impact categories, was 15 000 000 tCO_2e/year.

The lower limit for the ***High*** impact category was then taken as an order of magnitude less than the lower limit for the ***Very High*** impact category discussed above.

4.1.4.3 Summary of Impact Levels

Table 13 combines the above calculations into one impact table. This is used to assess the magnitude of the impact of a project on climate change. It also compares the thresholds to the low emission NDC carbon budget of 7 758 Mt CO_2e.

This assessment only considers emissions in the GHG inventory that occur with the boundary of South Africa. This ensures consistency in the impact assessment as the climate change impact assessment is a South African legal process. There is therefore no jurisdiction over emissions from international sources within this process. This also allows the emissions to be compared to the NDC which only considers the South African national GHG inventory.

---

29 Department of Environmental Affairs, 2017, *Technical Guidelines for Monitoring Reporting and Verification of Greenhouse Gas Emissions by Industry*.

30 Calculated from Eskom's 2021 IAR.

31 Electric Power Research Institute (2017). *Power Generation Technology Data for Integrated Resource Plan of South Africa*.

Table 13: Impact category thresholds used to determine the magnitude of the impact of the project on climate change.

GHG impact rating as a % of SA's carbon budget	Amount of GHG emissions		Relative to Low Emission NDC Carbon Budget	
	Lower limit (tCO_2e)	Upper limit (tCO_2e)	Lower limit (tCO_2e)	Upper limit (tCO_2e)
Low	-	30 000	0.000000%	0.00039%
Medium	30 001	1 500 000	0.00039%	0.019%
High	1 500 001	15 000 000	0.019%	0.193%
Very High	15 000 001	+	> 0.193%	

4.1.5 Limitations and Assumptions

This CCIA makes use of data obtained during a desktop review for the development of this GHG inventory and associated impact assessment. Certain assumptions were made to ensure the development of the most accurate and extensive GHG inventory and the associated impact assessment. These assumptions were made considering the significant boundary set out by the EIA reporting requirements. The assumptions are the following:

- The project developer was unable to supply details about the construction of the plant, the CCIA is therefore based on the assumption that the construction related emissions are immaterial in the context of the overall inventory.
- It was further assumed that the decommissioning phase of the project will not contribute material emissions when compared to the operational phase
- It was assumed that the following aspects of the Berenice Mine will contribute immaterially towards the GHG footprint of the project during the operational phase:
  - Quantity of construction and municipal waste generated, including the distance in transporting waste to landfill;
  - Purchase of capital goods, such as vehicles; and
  - Business travel.

The above assumptions were determined by applying the significance criteria in the SANS 14064-1:2021 standard. These assumptions are made based on the specialists' experiences.

4.2 Project Vulnerability to Climate Change

The impacts of climate change are likely to result in increased climate-related vulnerabilities for the Berenice Coal Mine Project. Climate change management should, therefore, not be limited to emissions reductions (mitigation) but should also take into consideration measures for increasing the resilience of the Project (adaptation) in the face of climate change. Identifying impacts of climate change on the Berenice Coal Mine Project will be considered in this assessment.

4.2.1 International Best Practice

Due to the current lack of local regulations regarding CCIAs in South Africa, specifically with regards to unpacking and quantifying vulnerability to climate change, international best practice is used in this assessment. In this regard, this report makes use of globally accepted international best practices, including:

- Framework for Climate Change Vulnerability Assessments,[32]
- International Finance Corporation (IFC) performance standards[33];
- European Bank for Reconstruction and Development (EBRB) principles;
- The Equator Principles[34]; and
- International Council on Mining and Minerals (ICMM): Adapting to climate change[35]

The abovementioned documents were used to develop a rating system (indicated in section 4.1.4 of this report), to which the current project is benchmarked. This enables us to adequately assess climate change impacts considering available baselines and relevant information.

4.2.1.1 Key Areas of Impact

The resilience and vulnerability assessment conducted for this CCIA considers four key areas[36] (listed in Table 14 below) related to the proposed Berenice Coal Mine Project that could be vulnerable to climate change impacts.

Table 14: Key areas of impact relevant for the Berenice Coal Mine Project.

Area of Impact	Relevance
The core operations;	These are operations that are performed by the Project and that its management has complete control over.
The project value chain (both upstream and downstream);	These are operations that are related to the Project, but its management does not have control over. These include activities of suppliers, customers, government, and the greater economic market.
The social environment (surrounding/impacted communities); and	This includes the people that are both directly and indirectly affected by the Project, such as employees, surrounding industry and local communities.
Broader environmental risks	This is related to the natural environment directly surrounding the operations of the Project. These include operations, as well as those of surrounding industries and the livelihoods of the local communities.

32 GIZ. 2014. The vulnerability sourcebook. Gesellschaft für Internationale Zusammenarbeit, Bonn, Germany.
33 International Finance Corporation, 2012, *Performance Standards*, [Online] Available at: https://www.ifc.org/wps/wcm/connect/Topics_Ext_Content/IFC_External_Corporate_Site/Sustainability-At-IFC/Policies-Standards/Performance-Standards [Accessed on 30/08/2020].
34 The Equator Principles Association, 2020, *Equator Principles EP4*, [Online] Available at: https://equator-principles.com/about/ [Accessed on 30/08/2020].
35 International Council on Mining and Minerals, 2013, *Adapting to a changing climate: implications for the mining and metals industry*. ICMM.
36 International Council on Mining and Minerals, 2013, *Adapting to a changing climate: implications for the mining and metals industry*. ICMM.

For widescale considerations of the impacts of climate change, all four of the abovementioned aspects could be impacted by climate change and the Berenice Coal Mine Project.

4.2.2 Data used

This vulnerability assessment refers to various data sources in the process of determining the critical vulnerability factors faced by the Project. These sources are explained in Table 15 below.

Table 15: Climate change related tools used throughout this CCIA

Tools and Data	Explanation of use
The WRI Water Aqueduct Tool[37]	This tool provides insight into the areas that experience different vulnerabilities to water stress, globally. On a regional level, these identified water-stressed zones are anticipated to impact on the operations and sustainability of various industrial activities, including that of the Project.
The GreenBook Tool[38]	The GreenBook provides a municipal overview of climate-related changes anticipated for 2050 in comparison to present-day climate. In addition, this tool looks specifically at South African municipalities and indicates the increasing vulnerabilities of certain regions and the associated economic, health and environmental impacts of these changing vulnerabilities.
CustomWeather Historical Data	CustomWeather provides historical precipitation data for the Berenice Mine Coal project. The data provided included historical rainfall data from 1998 to 2021. The data was then used to make projections on precipitation conditions of the area.
R Studio[39]	R Studio is an integrated development environment for R coding. The software was used in conjunction with the Mann Kendall trend test to test the statistical significance[40] of the historical data and identify if there is a trend present.
Local demographic factors	Local demographics were used to earmark particularly vulnerable communities, which may be impacted more intensely by climate change and/or the presence of the Project within the region.

37 WRI.org. 2021. Aqueduct Water Risk Atlas. [online] Available at: https://www.wri.org/applications/aqueduct/water-risk-atlas/

38 Greenbook.co.za. 2021. Green Book 1 Adapting settlements for the future. [online] Available at: https://greenbook.co.za/

39 RStudio Team (2021). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/.

40 Data is statistically significant if P-value is <0.05. The alternative hypothesis is therefore accepted, and a trend is present within the dataset.

These tools were used in conjunction with the information sheet received from the client and considering the specialist's background and understanding of climate-related impacts posed on the Berenice Coal Mine Project.

4.2.3 Determining project vulnerability and resilience

The overall vulnerability of the Project, and its surrounds to climate change impacts, can be determined by identifying the exposure, vulnerability, and adaptive capacity of the region in which the Project lies. The IPCC Sixth Assessment Report[41] defines vulnerability as: "*the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.*"[42] This definition aligns with the method of determining the Project's climate-related vulnerability, proposed Figure 3 below.

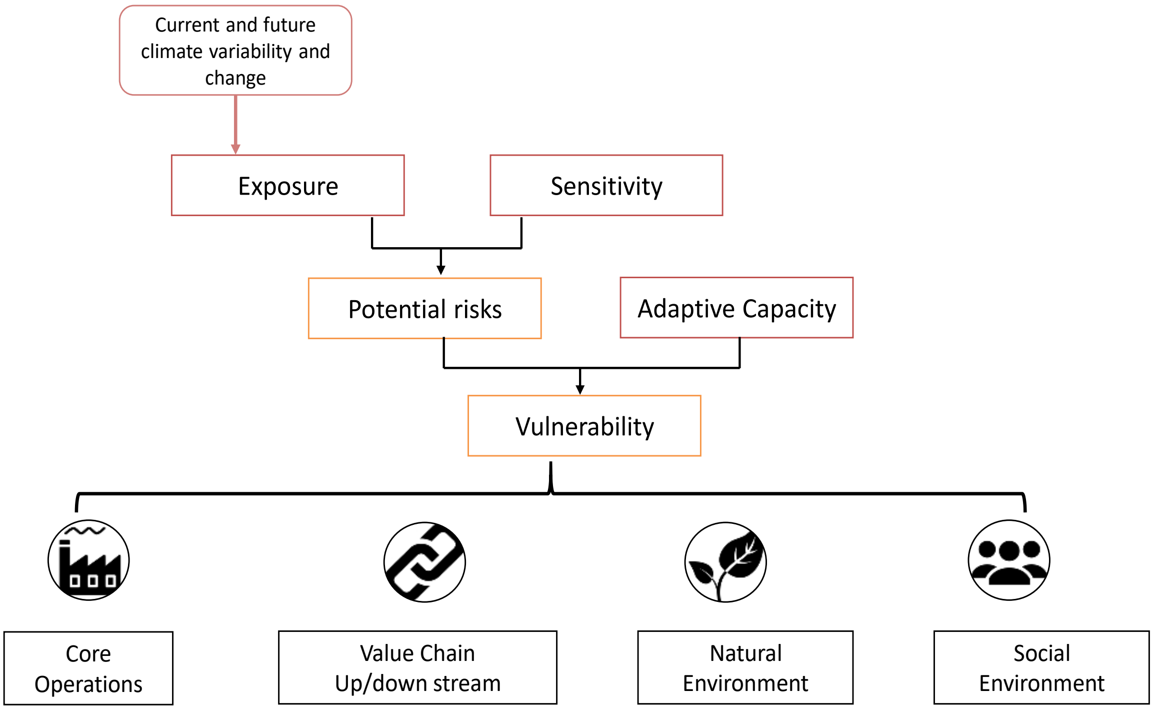


Figure 3: Interrelations of Exposure, Sensitivity and Adaptive Capacity, which makes up the basis of the vulnerability assessment

Figure 3 indicates the vulnerability of the core operations of the proposed Berenice Coal Mine Project, the value chain of the Project, as well as the social and natural environments surrounding the project. The diagram also illustrates how climate change impacts and variability could result in changes in the exposure levels experienced in this region.

41 IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.

42 IPCC, n.d., *Data Distribution Centre Glossary: Vulnerability*, IPCC [Website] Available at: https://www.ipcc-data.org/guidelines/pages/glossary/glossary_uv.html [Accessed on 10/08/2020].

The vulnerability assessment is conducted considering the impact of climate change on the region's exposure. Thereafter, the overall vulnerability is determined using project exposure, sensitivity, and the current-day adaptive capacity.

4.2.4 Limitations and Assumptions

The Project's vulnerability to climate change is assessed within this CCIA through an analysis of available datasets.

Climate projections at finer scales, such as at a municipal level, are much more challenging to project as opposed to subcontinental or continental scale. As a result, there are higher levels of uncertainty. Therefore, while confidence is growing in global climate models, there is a much greater appreciation of uncertainties involved in downscaling global models to illustrate climate projections at a local scale[43]. This is particularly relevant for rainfall projections where different climate change models are used. As such the latest climate change scenarios and projections were used in this climate change assessment.

This uncertainty should be noted by the project developers since the impacts of climate change may result in decreased investment value over time and possible increases in costs of maintenance.

The assessment of the vulnerability of the project to climate change is subject to further limitations, namely:

- Only impacts on the direct value chain were assessed;
- No modelling of climate change impacts was conducted; and
- Only impacts occurring during the lifetime of the project were considered.

5 Status Quo and Projected Climatic Changes

5.1 Mining Location and Climate

Two main sources of data, namely the province of Limpopo and site-specific data relating to the Vhembe District Municipality and the Makhado Local Municipality within which the Berenice Coal Mine project is situated, were analysed for climate forecasting. Based on the Greenbook and the data obtained, the historical weather data trends were used to forecast/foresee weather changes. These historical and projected weather trends are stipulated in the sections below.

It is important to note that climate change projections such as those included in the Greenbook, can in some instances indicate findings that appear contradictory, particularly with respect to rainfall. Most climate change models predict increasing variability of rainfall. This means that rainfall will be erratic. Periods of drought but then also periods of intense rainfall, are both plausible scenarios.

[43] Bourne, A, P. deAbreu, C. Donatti, S. Scorgie, and S. Holness. 2015. A Climate Change Vulnerability Assessment for the Namakwa District, South Africa: The 2015 revision. Conservation South Africa, Cape Town.

5.1.1 Regional Climate Change Considerations

The climate change projections for the Project within Limpopo indicate that annual average ambient temperatures are likely to increase by 1-2˚C in the near future. Furthermore, it is identified that Limpopo will experience decreased rainfall and be exposed to flooding, droughts, fires, and an outbreak of diseases (Figure 4).[44] Such climatic changes would have an impact on the Berenice Coal Mine project in terms of its core operations, value chain and broader socio-economic and natural environment.

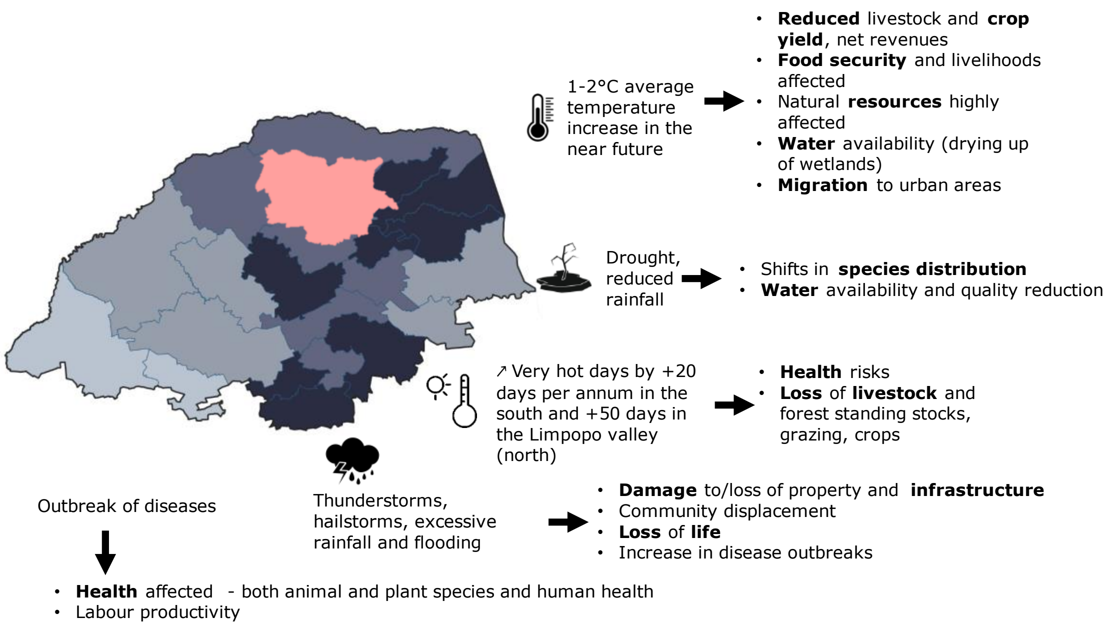


Figure 4: Climatic conditions predicted at Limpopo province.

The current and future changes in climate for the Berenice Coal Mine Project, are summarised in the table below.

Table 16: Current and future climate projections for the Berenice Coal Mine Project within the Makhado Local Municipality.

Climate change impact	Current	SSP 2	SSP 5
		The projected change for the period 2021 to 2050, relative to the baseline period (1961 to 1990).	
Temperature	Average annual temperature between 19 ˚C. to -22 ˚C.	Average annual temperature increases between 2.01°C to 2.55°C	Average annual temperature increases between 2.35°C to 2.69°C

[44] Mambo, J. and Faccer, K., 2017. South African Risk and Vulnerability Atlas: understanding the social & environmental implications of global change.

Climate change impact	Current	SSP 2	SSP 5
		The projected change for the period 2021 to 2050, relative to the baseline period (1961 to 1990).	
Very Hot Days (>35°C)[45,46]	The East and South is seen to have an increase of 11 to 30 hot days, while the North and West are seen to experience 30 to 50 more days of very hot days.	Potential increase of 14.56 days to 56.28 days	The average increase in the number of very hot days could increase between 17.50 days to 57.28 days
Rainfall	Average of 300mm to 400 mm in most regions, however the East is seen to experience 700 to 1400mm	Higher rainfall variability predicted. Average annual rainfall may decrease by 82.08mm in the case of drought conditions. Alternatively, an increase of 11.88mm in intense rainfall conditions.	Significantly higher rainfall variability. Average annual rainfall may decrease by 28.28mm in drought conditions. Alternatively, an increase of 51.40mm in intense rainfall conditions.
Extreme Rainfall Days[47]	*Information is not available for the baseline*	The region could experience a change of 0.88 days fewer extreme rainfall days or up to 0.30 days more. This corresponds to the higher variability above with drought conditions resulting in fewer extreme rainfall days and intense rainfall conditions resulting in more.	The region could experience a change of 0.24 days fewer extreme rainfall days or up to 1.40 days more. This corresponds to the higher variability above with drought conditions resulting in fewer extreme rainfall days and intense rainfall conditions resulting in more.
Flood Risk[48]	Medium in the North and South region while East has medium to very high risk and West region has a low to medium risk.	*Information is not available for the SSP 2 scenario*	Medium to high in some regions
Drought Risk [48,49]	Drought tendencies are increasing in the North and West region while the East and partial	*Information is not available for the SSP 2 scenario*	High to extreme in central region

45 Very hot days: the number of days (per 8 x 8 km grid point) where the maximum temperature exceeds 35°C.
46 Heat wave days: where temperature exceeds maximum temperature of the warmest month of the year by 5°C for a period of 3 or more consecutive days.
47 20mm of rain occurring within 24 hours over the 8 x 8 km grid point
48 Flood, drought and fire risk data were modelled for the RCP 8.5 scenario only (see greenbook.co.za), therefore no RCP 4.5 data could be included in this analysis. Floods, drought and fires are the most destructive and have the greatest environmental and social impact. RCP 8.5 scenario was selected to give a good indication of how climate change would precipitate as a function of the current conditions under these three aspects. Providing a current and worst-case scenario will help to provide a more conservative approach upon which actions can be based.
49 Number of cases exceeding near-normal per decade for the period 1995-2024 relative to 1986-2005 baseline period, under the low mitigation scenario.

Climate change impact	Current	SSP 2	SSP 5
		The projected change for the period 2021 to 2050, relative to the baseline period (1961 to 1990).	
	South region have a decrease in drought tendencies.		
Fire Risk [48]	Possible to likely in some regions	*Information is not available for the SSP 2 scenario*	High in central region

Climatic projections for the Berenice Coal Mine Project suggest that the area could experience an increase in average annual temperatures of at least 2°C to 2.5°C from the baseline period (1961-1990). It is further projected that annual average rainfall volumes would become more variable, and it is likely that there will be an overall decrease in rainfall. It is also seen that the Makhado Local Municipality will experience a drastic increase in extreme hot days for both SSP2 and SSP5. Hence, drought risks will increase due to temperature changes and increased variability in rainfall volumes and extreme hot days, and as a result, will influence the fire risk within the region, particularly within the SSP5 projection.

The main climate change impacts at the Makhado Local Municipality are increased temperature, extreme heat, increased rainfall variability and high risk to droughts. The climate in the area is thus likely to become hotter and drier.

5.1.2 Weather Trends and Projections

This analysis is based on the following datasets:

- CustomWeather Weather Data for the Berenice Coal Mine Project.
- World Resources Institute's (WRI) Aqueduct tool.

5.1.2.1 Temperature data

The temperature data provided by the Greenbook for the Makhado Local Municipality (Table 16), was used in this assessment. It is seen that the extreme hot days variable for the baseline (1961 to 1990) had an increase of 11 to 30 days in the East and South region, while the North and West experienced 30 to 50 increase of very hot days. Furthermore, it is also seen that drought tendencies increased in the North and West region. Therefore, from 1961 to 1990, it is seen that the Makhado Local Municipality became hotter and drier over time.

5.1.2.2 Rainfall data

Historical rainfall data from 1985 to 2021 for the Project was obtained from CustomWeather. The parameters analysed are *average annual rainfall*, *total days over average annual rainfall, total consecutive rainfall days over average*, and *total rainfall days*, such graphs can be seen in Figure 5.

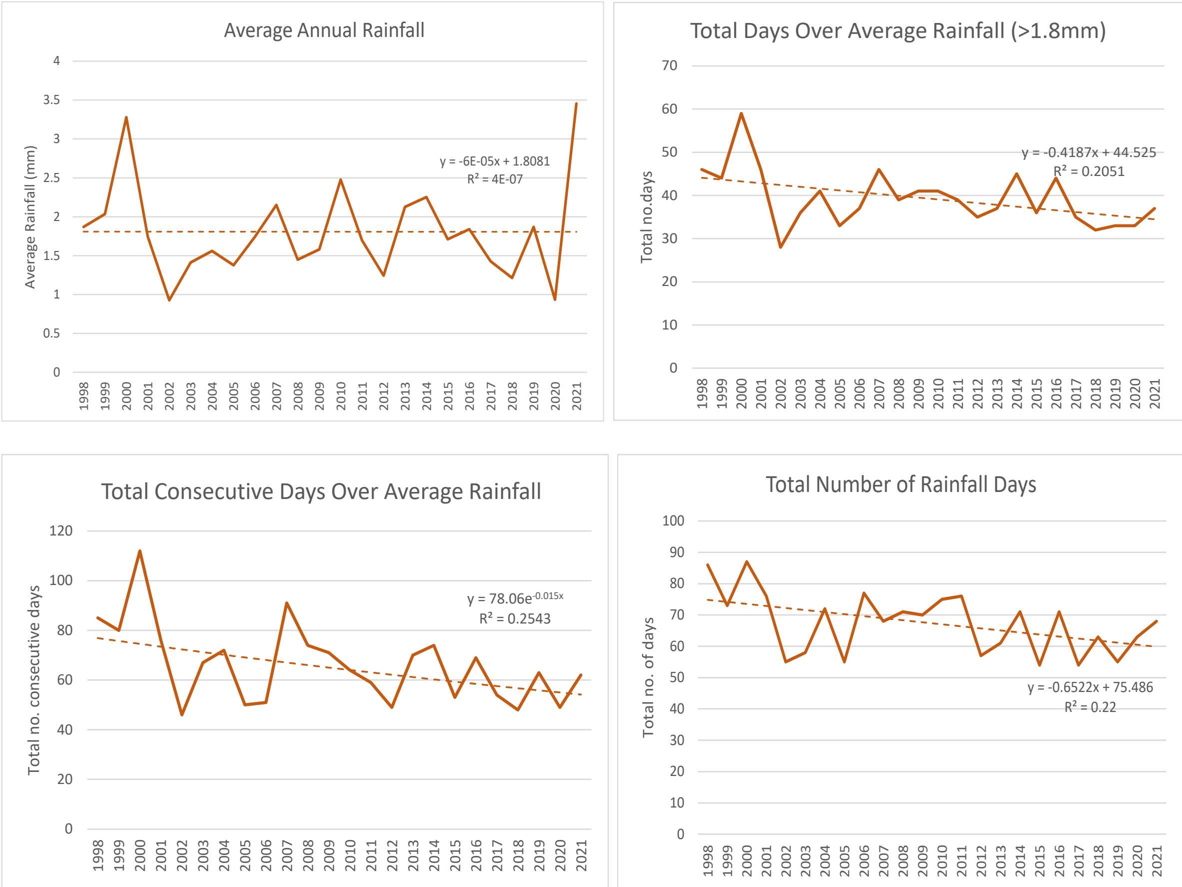


Figure 5: Historical precipitation data from 1985 to 2021 for the Berenice Coal Mine Project.

In the figure above, the rainfall parameters are showing a downward trend. Such trends reveal that the average annual precipitation, above average precipitation, and the amount of rainfall days experienced, has decreased from 1998 to 2021. In the software program R Studio, a Mann-Kendall test was used to test the statistical significance of the rainfall data. It was identified that the medium-term data above is statistically significant and reveals a downward trend in the dataset is present. Further information is depicted in the appendix. Furthermore, if we investigate longer-term data such as the Greenbook (Table 16), it is identified that the local municipality and project area is at risk to droughts in the future. Such data is significant information for this Project as numerous operations are sensitive to water availability and therefore should be considered.

5.1.3 Projected Climate Change

5.1.3.1 Temperature

The temperature projections are based on the information presented in Table 16. According to the table, it is seen that the extreme hot days will increase by between 15 to 56 days for SSP 2 and 17 to 57 days for SSP 5. Furthermore, it is seen that the annual temperature will increase by at least 2°C to 2.5°C from the baseline period (1961 to 1990). It is projected that there are high to extreme drought risks in the central part of the municipality, with further evidence expressed in the Makhado Integrated Development Plan. Hence, it is expressed that the municipality is likely to experience dry, hot conditions in the future.

5.1.3.2 Rainfall

Projected average annual rainfall of the Berenice Coal Mine Project from 1998 to 2040 is shown in Figure 6. By use of the regression line method, it is seen that a slight downward trend is present. In the software program R Studio, a Mann-Kendall test was used to test the statistical significance of the projected rainfall data. It was identified that the medium-term data below is statistically significant and reveals a slight downward trend in the dataset. Further information is depicted in the appendix. However, by use of such a method we are assuming the average annual rainfall will be a linear decrease. Such an approach is not entirely correct as there is variability within the rainfall data (which means it won't decrease linearly) and a standard decrease in forecasted values is not completely precise.

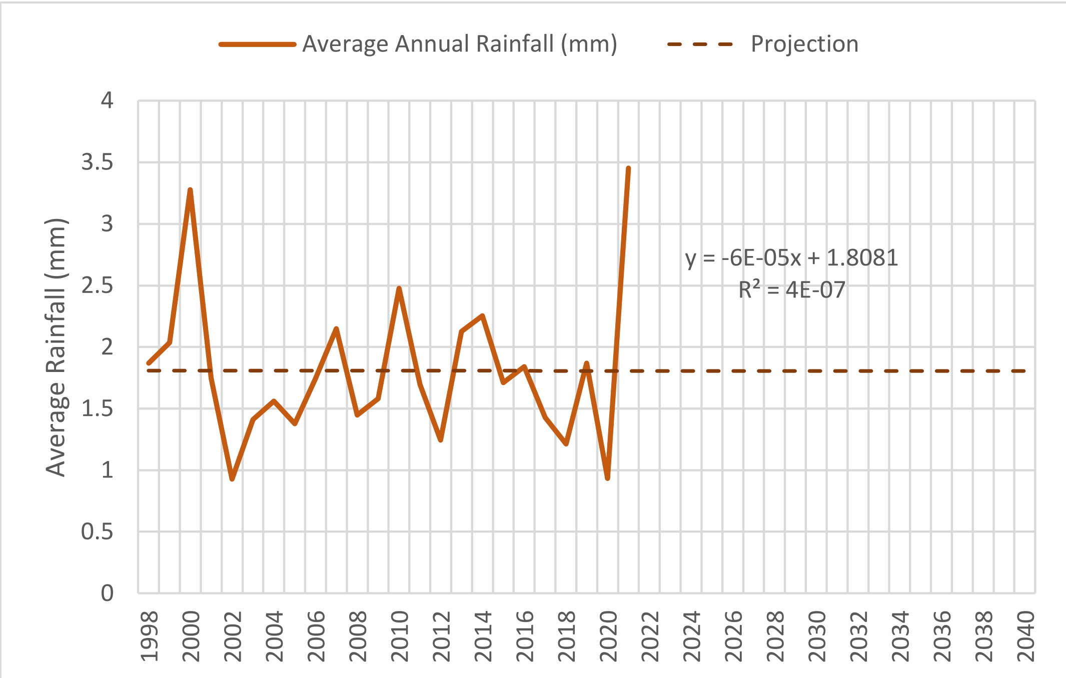


Figure 6: Projected annual rainfall for Berenice Coal Mine project from 1998 to 2040.

As a result of the conflict with the projection above, the rainfall projection information depicted in Table 16 will be used in conjunction. It is seen that that average annual rainfall may decrease by 80 mm or increase by 12 mm for SSP 2 and increase between 28 mm or decrease by 51 mm for SSP 5. Furthermore, the municipality could experience a change of 0.88 days fewer extreme rainfall days or up to 0.30 days more according to SSP 2, and 0.24 fewer extreme rainfall days or up to 1.38 days more according to SSP 5. As for the risks, it is seen that there is a medium to high risk of flooding in certain areas of the municipality, while central areas are exposed to high to extreme risks to droughts. Hence, Makhado municipality is likely to become drier in the future, with parts of the municipality predicted to experience floods. Lastly, according to the Makhado Integrated Development Plan, some of the identified hazards that pose the greatest risks to the municipality are floods, droughts, and extreme weather.[50]

[50] Makhado Municipality, 2019. Makhado Municipality Integrated Development Plan

5.1.3.3 Water Stress

Using the World Resources Institute's Aqueduct tool, the water stress in the Makhado region was analysed. The study area falls within the Limpopo province, and the Project is located in the Mopane section of the Karoo-aged Soutpansberg basin. Projected change in water stress shows how development and/or climate change are expected to affect water stress, which is the ratio of water use to supply. The "business as usual" scenario (SSP2 RCP8.5) represents a world with stable economic development and steadily rising global GHG emissions. By looking at the figure below, the projected increase in water stress is "low", suggesting that there is a <10% possibility that water stress will increase by 2030 within the projects area.

Figure 7: Projected change of water stress for the Berenice Coal Mine project.

The projected change in seasonal variability of water, based on the Aqueduct tool, is shown in Figure 8 below. Currently, the WRI Aqueduct Tool indicates that seasonal variability in the Project area is considered "Medium-High". According to the WRI, seasonal variability measures the average within-year variability of available water supply, including both renewable surface and groundwater supplies. Higher values indicate wider variations of available water supply within a year.

The projected change in seasonal variability of water moves from "Medium-high" to "High" in 2030 under a "business-as-usual" scenario. Lower values indicate narrower variations of available water supply within a year. This indicates that seasonal variability[51] may become more extreme in 2030. Figure 7 indicates projected change in water stress while Figure 8 indicates seasonal variability of water availability for the project area.

[51] Seasonal variability is an indicator of the variability between months of the year. Increasing seasonal variability may indicate wetter wet months and drier dry months, and higher likelihood of droughts or wet periods.

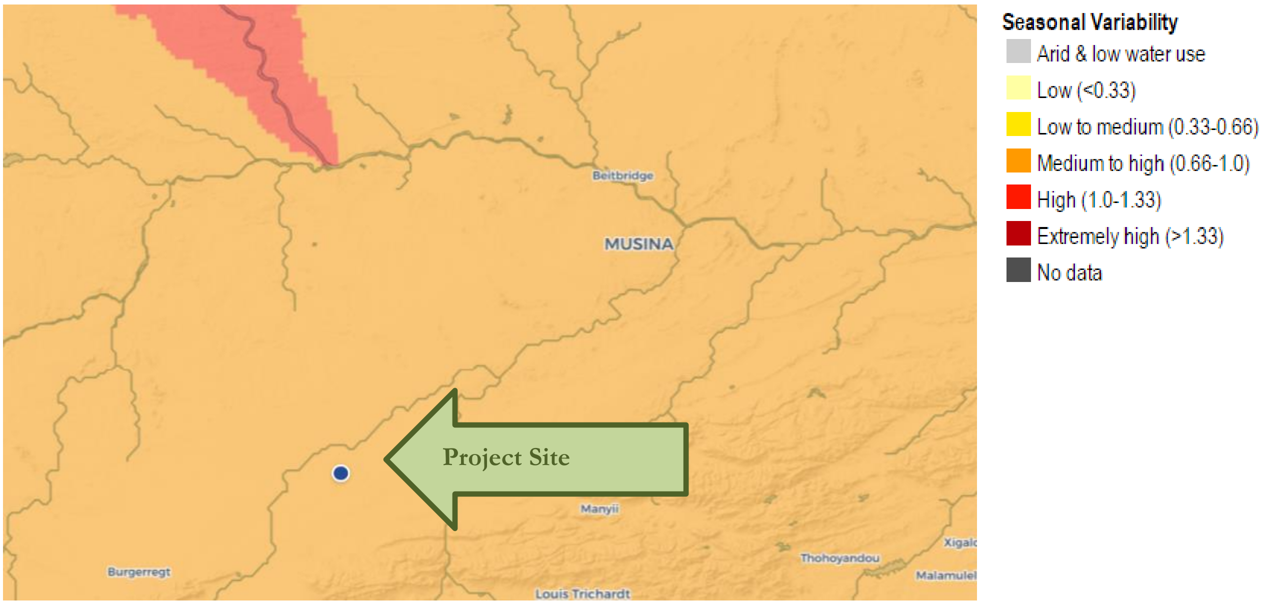


Figure 8: Seasonal variability at the Berenice Coal Mine Project.

6 Project Impact on Climate Change

The proposed Berenice Coal Mine will emit GHGs into the atmosphere. Section 6.1 quantifies the GHG inventory for the proposed Berenice Coal Mine, whilst Section 6.2 will look at the project's contribution to climate change in terms of its GHG emissions.

6.1 Project Greenhouse Gas Inventory

The GHG inventory for the proposed Berenice Mine was developed in accordance with the SANS 14064-1:2021 standard, as well as the GHG Protocol (ISO 14064-1:2006), as described in Section 4.1.1 above. Assumptions were made where necessary to overcome data gaps. Indirect emissions were included based on a significance assessment discussed in section 4.1.1.2. For the purposes of this CCIA, the GHG inventory according to SANS 14064-1:2021 was considered.

The boundaries of the analysis were set, as indicated in 4.1.1.2 above. This analysis took into consideration the relevant emissions from core operations, as well as upstream and downstream emissions.

Table 17 below shows the summary of the GHG inventory calculated for the Berenice Mine. The direct emissions will be in the order of 58 $ktCO_2e$/year, or 1 450 $ktCO_2e$ across the lifetime of the plant. The significant indirect emissions are 220 $ktCO_2e$/year, or 5 510 $ktCO_2e$ across the lifetime of the plant. Thus, the indirect emissions make up 80% of the total emissions considered in this GHG inventory.

The emissions related to the use of thermal coal should be excluded from the analysis. The volume of coal combusted in thermal power stations is set by the IRP irrespective of where that coal is sourced. As a result, Universal Coal has no influence over these emissions.

The emissions related to the use of coking coal should be excluded from the analysis as well. This coal is required for the production of steel which will be necessary to transition to lower carbon technologies. The production of steel occurs at operations outside of Universal Coal's operational control and therefore there is no influence over these emissions.

The excluded emissions are presented in Table 17 for completeness. These emissions were excluded when the impact of the project was calculated.

Table 17: Operation emissions for Berenice Mine– SANS14064-1 (2021).

Emission category	Emission source	Included/Excluded	Operation phase ($ktCO_2e/y$)	Total over life of project ($ktCO_2e$)
Category 1: Direct GHG emissions and removals)	Diesel Combustion	Included based on significance assessment	58 $ktCO_2e$	1 450 $ktCO_2e$
	Total direct emissions		**58 $ktCO_2e$**	**1 450 $ktCO_2e$**
Category 2: Indirect GHG emissions from imported energy	Electricity	Included based on significance assessment	118 $ktCO_2e$	3 000 $ktCO_2e$
	Fuel & energy related emissions not included in category 1	Included based on significance assessment	28 $ktCO_2e$	710 $ktCO_2e$
	Total Category 2 emissions		**146 $ktCO_2e$**	**3 670 $ktCO_2e$**
Category 3: Indirect GHG emissions from transportation	Employee commuting	Included based on significance assessment	0.2 $ktCO_2e$	6 $ktCO_2e$
	Transport of produced coking coal	Included based on significance assessment	64 $ktCO_2e$	1 600 $ktCO_2e$
	Transport of produced thermal coal	Included based on significance assessment	9 $ktCO_2e$	230 $ktCO_2e$
	Total Category 3 emissions		**74 $ktCO_2e$**	**1 840 $ktCO_2e$**
Total included indirect emissions			**220 $ktCO_2e$**	**5 510 $ktCO_2e$**
Total included emissions			**278 $ktCO_2e$**	**6 960 $ktCO_2e$**
Category 5: Indirect GHG emissions associated with the use of products from the organization	Combustion of thermal coal	Excluded based on significance assessment	7 820 $ktCO_2e$	195 400 $ktCO_2e$
	Use of coking coal	Excluded based on significance assessment	6 640 $ktCO_2e$	166 100 $ktCO_2e$
	Total Category 5 emissions		**14 460 $ktCO_2e$**	**361 500 $ktCO_2e$**

6.2 Project contribution to climate change

6.2.1 Transitioning to a 2-degree scenario

The Berenice Project produces coking coal as a primary product for the major Asian steel producing economies of China, Japan, India, South Korea and Taiwan. Steel will play a vital role in the global transition to a low-carbon economy. A recent World Bank report, *The Growing Role of Minerals and Metals for a Low Carbon Future*[52], estimated the global steel demand, for the period up to 2050, for several climate change mitigation scenarios. The report covers scenarios where the world economy implements interventions in line with 2°C, 4°C, and 6°C pathways.

According to the 2017 report, cumulative global demand for steel between 2013 and 2050 under a 4°C scenario will be approximately 1.4 billion tonnes. If the world moves to a 2°C scenario, the steel demand for the same period increases to around 2.4 billion tons for the same period. This means that an additional 1 billion tonnes of steel are required for the period up to 2050. This is an approximately 67% increase from the 4°C scenario.

The global increase in demand for iron and steel will be partially driven by the growth in demand for components used in renewable energy technologies. An increase in steel production is required for the transition to a low-carbon economy. This is highlighted by Figure 9 below from the World Bank report.

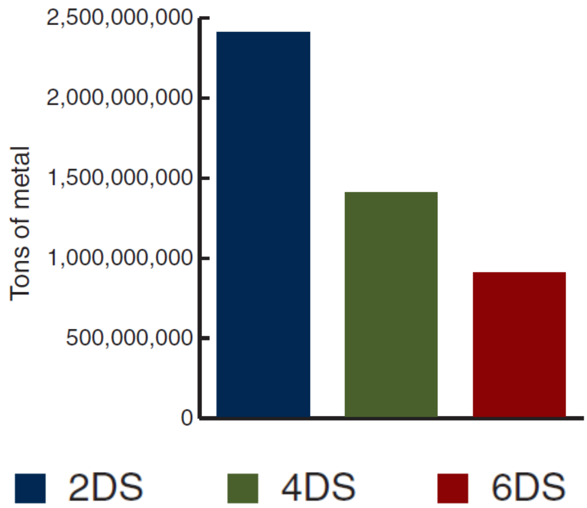


Figure 9: Global demand for steel

A second World Bank report, *Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition*[53], further investigates this global increase in demand for minerals and metals specifically in the energy sector. In Figure 10 below, the increase across the different minerals is shown. Iron, along with coking coal is a key component in steel production, is projected to have an increase in demand for a number of scenarios:

- Irena REmap scenario: 219% increase;

52 World Bank. 2017. *The Growing Role of Minerals and Metals for a Low Carbon Future.*
53 World Bank. 2020. *Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition*

- IEA B2DS (below 2 degree scenario): 81% increase;
- Irena Reference scenario: 73% increase; and
- Irena reference technology scenario: 10% increase .

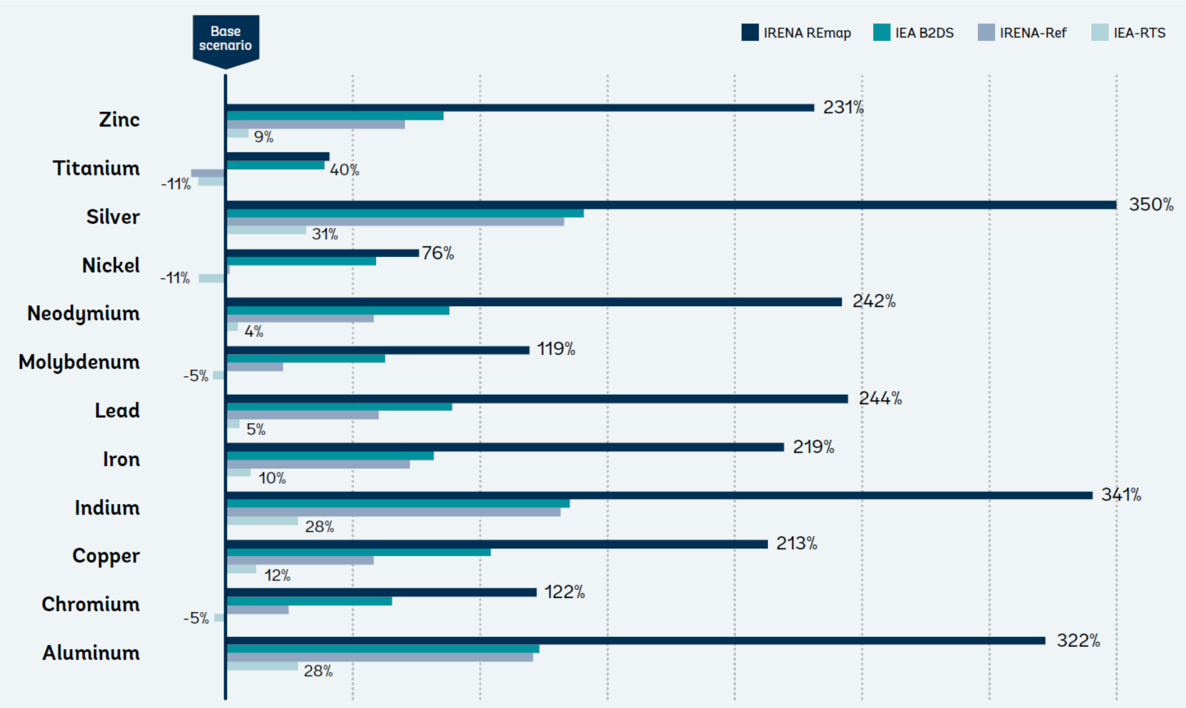


Figure 10: Global mineral demand increase

One example of the drivers of the increased demand for steel, and therefore coking coal, can be found in the expansion of the wind industry. The figure below shows the demand for iron (steel) in the wind industry for the period up to 2050.

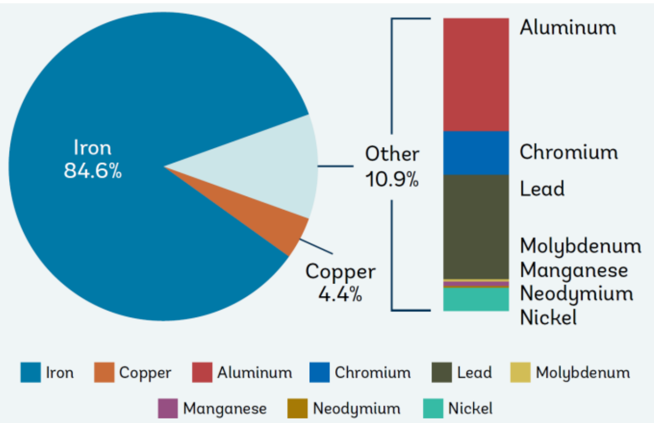


Figure 11: Share of mineral demand from wind energy under IEA 2DS through 2050 [54]

The 6th Assessment Report from the IPCC[55] estimates the annual emissions for various climate change scenarios. Based on these scenarios, there is a difference of 20GtCO_2 per annum by 2050 between SSP4.5 and SSP2.6. The IPCC 6th Assessment Report additionally projects the cumulative

54 World Bank. 2020. *Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition*
55 IPCC. 2022. *6th Assessment Report, Working Group I, Summary for Policy Makers*

emissions as shown in Figure 12. Using this figure, the cumulative emissions under a 2°C and 4°C scenarios were estimated. The difference between these two figures is approximately 4 200 $GtCO_2$.

The above value was calculated by obtaining the difference between the projected cumulative emissions under 2°C and 4°C warming, as presented in Figure 12 below. The resulting emissions abatement was divided by the 1 billion tonnes of cumulative steel demand to obtain 4 128 tCO_2 abatement per tonne of steel produced. The production of steel requires in the order of 0.77 tonnes coking coal per tonne steel produced. The production of one tonne of coking coal therefore relates to the potential reduction of emissions of 5,361 tonnes CO_2e in emissions by playing a catalytic role in the provision of the raw materials needed to move from a scenario in which the global average increase in temperature is 4°C to 2°C above pre-industrial levels.

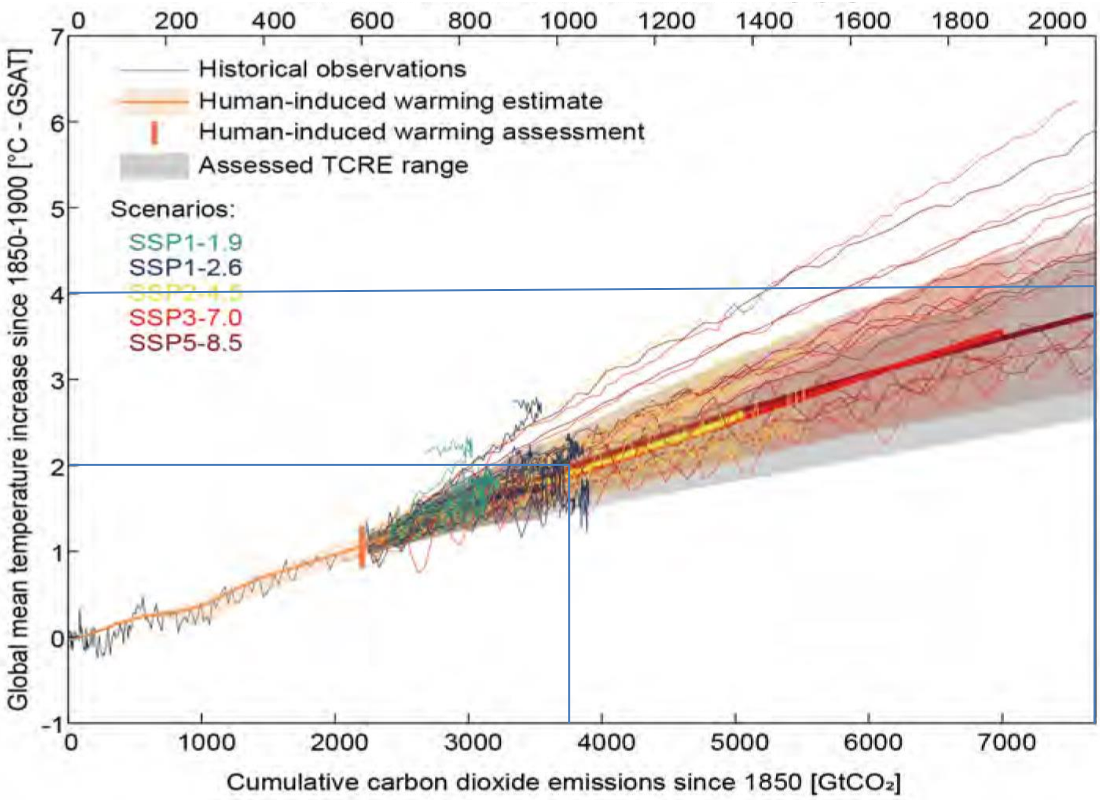


Figure 12 Projected global cumulative emissions[56]

The proposed Berenice Mine will lead to direct emissions emitted within the national boundary of South Africa as well as indirect emissions emitted nationally and internationally. Table 18 discusses these emissions in the terms of the impact of the proposed project within the context of the environmental authorisation process.

6.2.2 Causal Chain

The coking coal, and subsequent steel, from the Berenice Mine is an enabler for moving the global economy to a 2°C scenario. In the context of the analysis presented above, the project could result

[56] IPCC. 2021. Climate Change 2021 *"The Physical Science Basis Working Group I contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change"*

in 3 200 tCO_2 abated by the global economy for every tonne of coking coal produced. This equates to 281 GtCO_2 potential abatement over the life of the mine. The life cycle emissions of the coal produced by the Berenice mine is 20 tCO_2e/tonne coal mined. The production of coking coal from the Berenice mine could therefore enable the reduction of 267 tons of CO_2e emission reduced per ton of CO_2e emitted in the life cycle of the coking coal.

The Berenice Mine will also produce thermal coal for use in thermal power stations in South Africa. As Universal Coal has no influence over the emissions from the combustion of this coal, they have been excluded from this analysis. Furthermore, the quantity of thermal coal required is set by the IRP and this coal will be combusted regardless of whether the Berenice Mine is approved or not.

6.2.3 Assessment Criteria

The Berenice Mine has a significance score is calculated in Table 18 below, using the impact methodology described in Section 4.1.3 above. This means that the project has a ***High*** positive climate change impact due to the potential contributions and emission abatement in the steel industry.

Table 18: Climate Change Impacts of the Berenice Mine.

<table>
<tr><td></td><td colspan="2">Nature: The proposed Berenice Mine is a thermal and metallurgical coal mine. It will consume diesel and electricity in mining machinery. The combustion of this diesel will result in direct emissions and the production of the electricity in indirect emissions.
The manufacture and transport of fuels (such as the diesel) will also lead to the release of GHG emissions. These emissions are indirect emissions.
The emissions taken into consideration within the context of this impact assessment are all emissions considered significant based on the significance assessment. This includes the direct emissions from the combustion of the diesel and the indirect emissions relating to the generation of electricity. The Berenice Mine direct and indirect GHG emissions total 278 ktCO_2e/year.</td></tr>
<tr><td></td><td>Description</td><td>Score</td></tr>
<tr><td>Extent (E)</td><td>The GHG emissions of the project will contribute to global climate change. The extent of the impact is therefore global</td><td>5</td></tr>
<tr><td>Duration (D)</td><td>CO_2 released into the atmosphere stays in the atmosphere for at least 100 years. The duration of the impact is therefore permanent.</td><td>5</td></tr>
<tr><td>Magnitude (M)</td><td>The magnitude of the impact is:
• Coking coal: The GHG emissions of the mining and use of the coking coal amounts to 1 Gt CO_2e over the life of the mine. In</td><td>7</td></tr>
</table>

	contrast to this amount, the contribution the coking coal can make to the production of steel that is required for the transition of the world economy from a 4°C scenario to a 2°C scenario could assist with the abatement of 281 Gt CO_2e. The mining of coking coal therefore has **VERY HIGH** positive rating • **Thermal Coal**: The GHG emissions from the use of thermal coal is not attributable to this project, as the burning of coal for the production of electricity in South Africa is dictated by the IRP. The mining of thermal coal therefore has a **LOW** rating. The overall rating of the magnitude is therefore **HIGH**	
Probability (P)	The IPCC attributes emissions as one of the main reasons for climate change with 95% certainty. Therefore, the probability of the impact is considered as definite.	5
Significance (S)	The significance points are calculated as: S = (E + D + M) x P. Therefore: S=(5+5+7) x 5=85	85
	Mitigation: There are no mitigation options considered in this analysis based on the current economic conditions with respect to electricity and diesel supply.	
	Residual risks: The residual risk remains high, due to the potential impact of climate change, despite mitigation efforts.	

7 Project Vulnerability to Climate Change

Vulnerability is defined as the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes[57]. The figure below shows the vulnerability of the Makhado Local Municipality to climate change risks including fire, flood, drought and extreme hot days.

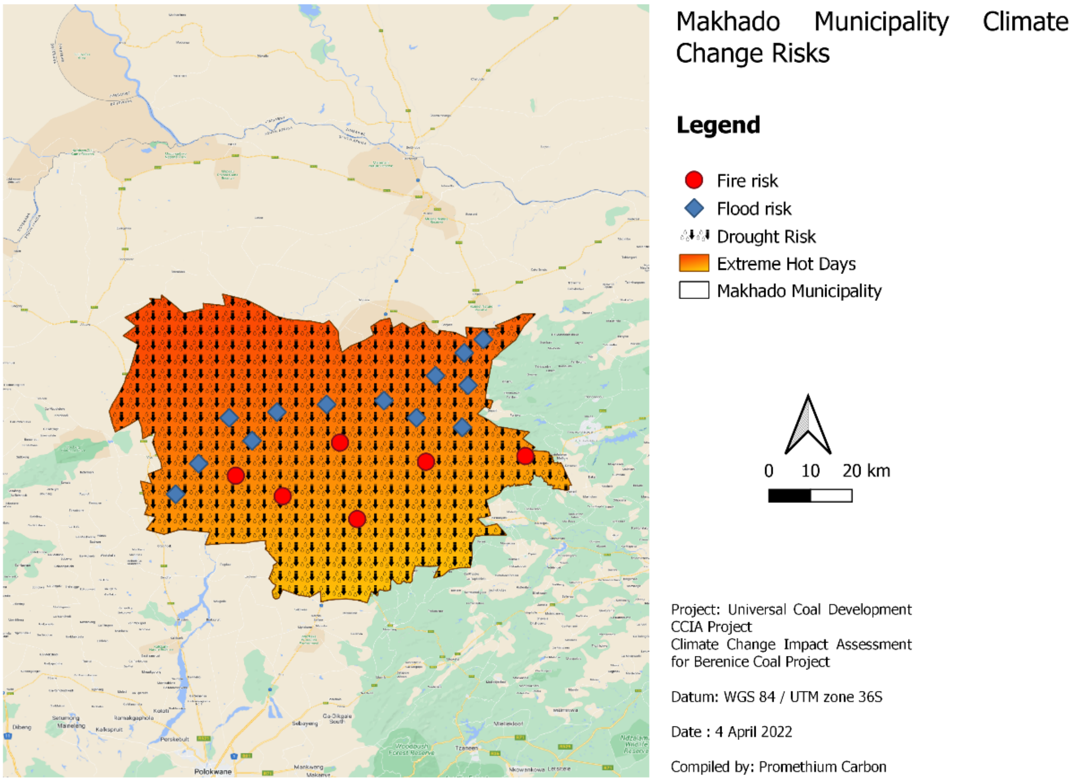


Figure 13: Makhado Local Municipality Climate Risks: fire, flood, drought, and extreme hot days.

Natural and manmade hazards or disasters affect the Vhembe District Municipality. This could also have an impact on both national, provincial and the districts and sub-districts development initiatives. The key disaster profiles for the municipality include hydrological, biological, environmental, and geological hazards. Disaster profiles that have been reported for the province correlate to the trends displayed in the GreenBook Tool. The climatic conditions profiled by the GreenBook indicate that the main climate change impacts at the Makhado Local Municipality are increased temperature, extreme heat, increased rainfall variability and high risk to droughts. The climate in the area is thus likely to become hotter and drier. This will lead to environmental hazards that will affect natural resources, water availability to wetlands, shifts in species distribution and land degradation. The municipality may also be exposed to flood risks which can lead to environmental hazards such as soil erosion, landslides and sink holes caused by heavy rainfall. In

[57] IPCC, 2022: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. In Press.

the project context, the Berenice mine will accommodate a 1:100 storm period to account for extreme weather such as storms and floods.

Table 19: Disaster risk Profile relevant to climate change for Vhembe District Municipality[58]

Hydro- Meteorological	Environmental Hazards	Geological Hazards
Flood	Air pollution	Landslides/mudflow (can be exacerbated through extreme weather such as floods)[59]
Drought	Deforestation	
Hailstorms	Land degradation	Sinkhole (can be caused because of heavy rains and floods)[60]
Cyclone	Soil erosion	
Severe Storms	Environmental degradation	
Hurricane		
Fire		
Heatwaves		

The Makhado Local Municipality Annual Report 2020/2021[61] published the following disaster incidents presented in Table 20. The occurrence of fires/storms and flood incidences increased since the 2018/2019 reporting year. The Makhado Local Municipality has since conducted disaster relief programmes which have increased in 2020/2021 since 2018/2019. The variations of incidences that have been reported were also due to different challenges of climate change experienced in each of the years compared to the review year 2020/2021. Tropical Cyclone Eloise, which resulted in continuous rain, resulted in many families being displaced within Limpopo, particularly within the Vhembe District Municipality and the Makhado Local Municipality[62]. Within the Vhembe District Municipality, several houses and infrastructure such as bridges were damaged. The floods have also resulted in road closures within the rural areas.

Table 20: Disaster Incidences in the Makhado Local Municipality[63]

Incidence	2018/2019	2019/2020	2020/2021
Fire incidence	50	33	56

58 Vhembe District Municipality, 2020/21 Draft Integrated Development Plan Review, Page 63, [Available online]: http://www.vhembe.gov.za/media/content/documents/2020/2/o_1e4eguteaaief221sgtrc5tpan.pdf?filename=VHEMBE%20DISTRICT%20MUNICIPALITY%202020%20l%202021%20Draft%20IDP%20DOCUMENTS.pdf (Accessed 19 April 2022).

59 Odhiambo,B.D.O., Kataka,M.O., and Mashudu, M., 2019: The use of remote sensing to map landslide prone areasin Makhado municipality of Limpopo Province, South Africa, Contributing Paper to GAR 2019 [Available online]: https://www.undrr.org/publication/use-remote-sensing-map-landslide-prone-areas-makhado-municipality-limpopo-province (Accessed 28 April 2022).

60 Construction Safety, 2022: Flooding causes damage to roads in Limpopo [Available online]: https://www.constructionsafety.co.za/2021/01/25/flooding-causes-damage-to-roads-in-limpopo/ (Accessed 28 April 2022).

61 Makhado Local Municipality Annual Report 2020/2021 [Available online]: http://www.makhado.gov.za/sstaff/pages/sites/makhado/documents/annual_reports/DRAFT%20ANNUAL%20REPORT%20_2020-2021_FINANCIAL%20YEAR.pdf (Accessed 12 April 2022)

62 Reliefweb: 2021: Relief for flood-hit Limpopo residents, [Available online]: https://reliefweb.int/report/south-africa/relief-flood-hit-limpopo-residents (Accessed 19 April 2022)

63 Makhado Local Municipality Annual Report 2020/2021 (Page 57) [Available online]: http://www.makhado.gov.za/sstaff/pages/sites/makhado/documents/annual_reports/DRAFT%20ANNUAL%20REPORT%20_2020-2021_FINANCIAL%20YEAR.pdf (Accessed 12 April 2022)

Storms/Floods	74	4	109
Disaster relief programmes	27	37	138

7.1 Core operations

Mining companies in South Africa are already experiencing detrimental climate change impacts. These include, for example, prolonged regional droughts which result in water constraints and operational stoppages as well as flash floods impacting water storage facilities and water discharge quality The timing and magnitude of these effects are uncertain. To account adequately for the potential climate change effects in planning processes, companies need to consider how climate related risks and opportunities, as well as the associated impacts, may evolve under different conditions. The core operations of the Berenice project are related to the plant facilities and site operations. Physical structures may be at direct risk from weather extremes and may cause physical damage. Climate change may also affect the efficiency of production processes on site, cost of operations and maintenance.

7.1.1 Physical Risks

Such risks relate to the direct impacts climate change conditions may have on numerous sectors of society and the environment. With relevance to the Berenice project, the physical risks look at the impacts temperature and rainfall will have on the project, as well as the labour and working force.

7.1.1.1 Temperature

It is expected that the Makhado Local Municipality will experience an increase in average temperature, as well as an increase in the frequency of hot days. The GreenBook tool indicates that by 2050, the average temperature will increase by between 2.01°C to 2.5°C under the SSP 2 (RCP 4.5) scenario and between 2.39°C to 2.69°C under an SSP 5 (RCP 8.5) scenario. The number of very hot days is also predicted to increase by up to 15 days under SSP2. Typical risks associated with the relationship between increased temperatures and mining, include the following:

- The increased annual temperatures and an increased frequency in the number of hot days/ heatwaves, will result in equipment thresholds being exceeded more frequently
- Higher atmospheric temperatures will also result in increased water losses due to evaporation, which will pose increased strain on water sources due to decreasing water availability.
- In addition, the onsite offices will make increased use of air conditioning due to higher temperatures, thus increasing the energy demand and associated costs.

7.1.1.2 Rainfall

It is expected that annual rainfall trends will decrease with an increase in rainfall variability and high drought risk in specific regions of the Makhado Local Municipality. The operation of the

Berenice Project is dependent on water availability for its operations. Therefore, reduced rainfall has the potential to impact the operations and production for the Berenice Project.

7.1.2 Labour and working conditions

In terms of the Berenice Project's workforce, the existing hot and dry environment, coupled with expected increase in the number of extreme hot days, could have a negative impact on the health of employees, particularly for individuals working outside who are exposed to extreme heat.

The Berenice Project will employ 511 people within the first year of operations. The workforce shall be sourced from the Vhembe District Municipality and the Makhado Local Municipality. The Berenice project, through its contribution to mining and coal related industries will thus contribute towards job creation which will equate to a larger workforce in the local area.

The climatic trends for the region indicate that the area will experience an increase in the number of hot days under the SSP 2 and SSP 5 scenarios. From an operational perspective the impact on the workforce for the project, could negatively affect employees that are exposed to extreme heat stress. This workforce includes miners, engineering foreman, surveyors, artisans and any other employees required to do on-site work related to the mine. Jagarnath *et al* (2020)[64], indicate that heat stress because of climate change is projected to increase and will become a future concern mainly as a function of social vulnerability due to demographics and characteristics of the local setting.

Heat stress will also be a major occupational health risk and can directly impact labour productivity and consequently, operations at the Project site. High heat exposure restricts an employee's physical functions, their capabilities and ultimately, work productivity and capacity.

In addition, increased drought spells will result in greater onsite water needs due to increased dehydration, as well as an increased investment required in employee health care systems. The local employees will also be increasingly exposed to heat-related illnesses, such as heat stroke and dehydration, which could affect the number of sick leave days employees require.

7.2 Value chain

Analysing the impact climate change will have on the value chain at the Berenice Project will allow for an understanding of how materials, equipment, and resources (upstream), and manufacturing, production, and distribution (downstream) process, will be affected.

7.2.1 Upstream value chain

The upstream value chain for the Berenice Project will be impacted by climate change, as indicated for the main items used in the Project, in Table 21 below.

---

64 Jagarnath, M., Thambiran, T., and Gebreslasie, M., 2020: Heat stress risk and vulnerability under climate change in Durban metropolitan, South Africa-identifying urban planning priorities for adaptation, *Climate Change,* 163, 807-829.

Table 21: Climate change impacts on the upstream value chain of the Berenice Project.

Item	Aspects affected by the impacts of climate change
Electricity and Diesel	Climate change risks associated with the electricity (such as the disruption of electricity supply due to water scarcity) and diesel (such as extreme weather impacts on trade routes) supply chains are considered commercial risks which should already be taken into consideration by the project developer.
Transport and storage of all goods	It is anticipated that diesel will also be used onsite for machinery and generators. Similarly, all equipment and other such goods will be transported to the project site. These items will make use of the well-established road networks in and around the Makhado Local Municipality. *Increased temperatures* Increasing ambient temperatures and extreme hot days increases exposure to heat and in turn, heat stress. Heat stress at work, as result of (climate-related) increasing temperatures, impacts workers health, safety, productivity, and social well-being. Therefore, the projects transport of goods and services workers may be exposed to heat stress and increased temperatures and will inevitably impact operations. In addition, storage areas for the various goods used by the project may experience increased temperatures and possible damage, thus causing delays in product deliveries to the project site. *Extreme weather events.* With increased rainfall variability, the Berenice project may be exposed to erratic rainfall, periods of drought, but then also periods of intense rainfall. Increased flooding may also lead to pipeline damages, resulting in potential water supply constraints. This could lead to decreased road access to the project and cause delays in product deliveries to the Project site.

7.2.2 Downstream value chain

The downstream value chain for the proposed Project will also be impacted by the effects of climate change, as indicated in Table 22 below.

Table 22: Climate change impacts on the downstream value chain of the Berenice Project

Item	Aspects affected by the impacts of climate change
Road access	*Extreme weather events.* With increased rainfall variability, the Berenice Coal Mine Project may be exposed to erratic rainfall and periods of drought, but then, also periods of intense rainfall. This could lead to decreased road access (due to roads/bridges being washed away during flood or storm events) to the location and disrupt the distribution of supplies.
Rail Lines	*Extreme weather events.* The impacts of extreme weather events could damage rail infrastructure within the project site, because of the highly integrated nature of the rail system and the need to maintain safe operations.
Sewerage treatment plants	*Extreme weather events* Consideration for extreme weather such as floods should be carefully considered. The impact of extreme weather events may lead to untreated sewer overflows, and increased flooding from wastewater related to the mine. Extreme weather range will possibly lead to more untreated wastewater.

7.3 Broader Social Context

Promethium understands that a social specialist study will be undertaken by Urban-Econ Development and Economists and will include a Social Impact Assessment (SIA). This CCIA will therefore not provide details with respect to demographics, inequality, education, employment, household income or service delivery for the local municipality.

We do however note the following key points that should be considered with respect to climate change and the broader local community:

- With respect to the demographic profile, women are generally considered to be more vulnerable to climate change than their male counterparts, as women generally head up the household whilst males leave to urban centres, as a result, firewood and water collection is often a women's primary responsibility;
- A high unemployment rate points to existing socio-economic vulnerabilities. High levels of poverty, low-income distribution and low education levels all contribute to vulnerability. Social vulnerability from climate change will result in further inequalities and reduced capacity to cope with climate shocks; and
- A local community that is largely younger than 15 or older than 65 indicates a higher dependency ratio. Increased economic strain on households can lead to increased vulnerability to climate change impacts.

7.4 Broader Environmental Context

In addition to this specialist CCIA, other specialist studies have been conducted for the Berenice Coal Mine, specifically:

- Geology;
- Hydrogeology;
- Hydrology;
- Terrestrial Biodiversity;
- Aquatic Biodiversity; and
- Soils and Agricultural Potential.

This CCIA will therefore not provide additional details with respect to the above-mentioned disciplines.

We do however note the following key points that should be considered with respect to climate change and the broader environmental context:

- Climate change will affect natural ecosystems, reducing their ability to withstand impacts. The continued loss of biodiversity and degradation of ecosystems, and impacts to water resources weakens their ability to provide essential services.
- A RAMSAR recognised wetland (Makuleke) has been identified within the Vhembe District Municipality. Wetlands have important regulatory functions in that they moderate floods. They allow for attenuation of flood peaks thus reducing the risks to people and infrastructure. In addition, wetlands improve water quality though filtration and detoxification.

8 Project Mitigation and Adaptation Measures

Mitigation and adaptation measures will need to be addressed. The Berenice Project could consider reducing its *impact on climate change*, as well as the measures needed improve the *resilience of the project to climate change*. These are discussed further below.

8.1 Measures to reduce the impact of the Project on Climate Change

We do not see any significant mitigation options available to the Berenice Mine within the current economic circumstances with respect to diesel and electricity supply.

8.2 Adaptation Measures to Increase the Project's Resilience to Climate Change

As described in Section 7 of this report, climate change impacts will influence Berenice Coal Mine operations, as well as the surrounding communities and broader natural environment. However, there are several adaptive measures that the Project can take to improve the operation's resilience to the identified climate change impacts. Adaptation measures which are already being considered by Universal Coal and those which can be considered in the operation's future include:

1. The Berenice project will rely on the extraction of ground water from well fields for its operations, in this respect the ground water specialist should carefully consider the risks associated with ground water extraction and climate conditions that can facilitate suitable measures to protect groundwater resources.
2. As already mentioned, the project plans to use recycled water for the washing plant to minimise the use of ground water. We recommend that this is pursued.
3. The project plans to install a pollution control dam that has a 1:100 stormwater threshold. We recommend that the design capacity of this dam is maintained.
4. Continually improving risk management systems and onsite employee training specifically for extreme weather events, such as extreme heat and heavy rainfall.
5. Reducing the requirement for freshwater for mine processes with a sufficient water treatment plant. Universal Coal has already implemented a small one for staff water requirements.
6. The mine health and safety plan should also consider work practices to manage heat stress and temperature extremes for workers. This could consider the following measures:
   - Rotation of mine site staff on hot days,
   - Wearing of protective safety or reflective clothing when exposed to the sun or being outdoors to absorb the radiant heat,
   - Heat-related incidences should also be reported as part of the mine health and safety to have such records for future heat related stress,
   - Provision of work-rest procedure -frequent breaks and short work periods

9 Opinion of the Project

The assessment of the climate change impact of this project has been done on the impact of the project on climate change, the resilience of the project to climate change, as well as the options for mitigation of the impacts.

The impact of the project on climate change was assessed in the context of both GHG emissions from the project, as well as the potential positive impact the project will have for the transition to a low-carbon economy.

The project will emit 14 460 ktCO_2e/year during the operational phase and 361 500 ktCO_2e over its lifetime. The global economy will not be able to move to a lower GHG emissions scenario (or 2°C scenario) without a substantial increase in renewable energy infrastructure development, which will require steel and coking coal. The Project will therefore have a positive net climate change impact.

In accordance with the findings of this CCIA, we advise that the proposed Berenice Coal Mine should not be refused environmental authorisation on the basis of climate change related issues.

Appendix A: GHG Emissions according to the GHG Protocol

Emission category	Emission source	Operation phase	Total over life of project (25 years)
Scope 1: Direct emissions	Diesel (Combustion)	57 800 tCO_2e	1 450 000 tCO_2e
	Total direct emissions	**57 800 tCO_2e**	**1 450 000 tCO_2e**
Scope 2: Indirect GHG emissions from imported energy	Electricity	118 000 tCO_2e	2 960 000 tCO_2e
Scope 3: Other Indirect emission	Category 3: Fuel- And Energy-Related Activities	28 400 tCO_2e	710 000 tCO_2e
	Category 7: Employee commuting	250 tCO_2e	5 900 tCO_2e
	Category 9: Downstream Transportation and Distribution	73 400 tCO_2e	1 835 500 tCO_2e
	Category 11: Use of Sold Products	14 460 000 tCO_2e	361 461 000 tCO_2e
	Total Scope 3 emissions	**14 561 000 tCO_2e**	**364 013 000 tCO_2e**
Total Indirect Emissions		**14 680 000 tCO_2e**	**367 000 000 tCO_2e**
Total Emissions		**11 778 212 tCO_2e**	**368 400 000 tCO_2e**

Appendix B: Statistical Significance of Historical Data

Historical Rainfall	Mann Kendall Trend Results
Annual Average Rainfall	tau = -0.1, 2-sided p-value = 0.00938
Over Average Rainfall	tau = -0.115, 2-sided p-value = 0.00417
Consecutive Days of Over Average	tau = -0.113, 2-sided p-value = 0.00432
Total Rainfall Days	tau = -0.137, 2-sided p-value = 0.000498
Projected Rainfall	
Annual Average Rainfall	tau = -0.506, 2-sided p-value = 5.472e-12