APPENDIX L: CLIMATE CHANGE ASSESSMENT

PROMETHIUM CARBON

Specialist Climate Change Impact Assessment Report

For the proposed

Black Mountain Mining (Pty) Ltd. Gamsberg Smelter Project

Prepared by Promethium Carbon
for SLR Consulting (South Africa) (Pty) Ltd

August 2020

Executive Summary

The Gamsberg Zinc Mine forms part of Black Mountain Mining (Pty) Ltd a subsidiary of Vedanta Resources PLC mining group. The Black Mountain Complex (BMC) consists of the Black Mountain Mine and Gamsberg Zinc Mine. The BMC mines zinc, lead, silver and copper with a production capacity of 90 000 tpa metal-in-concentrate. Of this, 250 000 tpa of zinc concentrate originates from the Gamsberg operations and is intended to be processed into final zinc metal at the proposed Gamsberg Smelter.

The Gamsberg Zinc Mine is currently in the operational phase and comprises the following, as per received information:

- Open pit zinc mine (currently 4 mtpa ore capacity, approved to mine up to 10 mpta);
- Concentrator plant (250 – 300 ktpa);
- Tailing storage facility; and
- Employee housing.

Black Mountain Mining (Pty) Ltd intends to extend the scope of the Gamsberg Zinc Mine by developing a Smelter Complex at the Gamsberg Zinc Mine site to process the concentrate and produce refined zinc metal product. The Gamsberg Smelter Complex is expected to have a capacity of 300 ktpa of finished zinc metal and will produce two main by-products as waste, namely 450 ktpa of sulphuric acid and 13 ktpa of manganese dioxide residue.

Promethium Carbon has been appointed to undertake a Climate Change Impact Assessment as part of the Environmental Impact Assessment (EIA) process for the Gamsberg Smelter Project. In accordance with the relevant regulations, an EIA process must be completed and approved by the relevant competent authorities before the project development can proceed.

A Greenhouse Gas (GHG) inventory of the proposed Gamsberg Smelter Project was compiled to quantify the effects of the proposed project on climate change. This inventory determined the Scope 1 (direct GHG emissions), Scope 2 (energy indirect emissions) and Scope 3 (other indirect emissions) emissions related to the proposed Gamsberg Smelter Project and other associated operations. Direct, Scope 1, GHG emissions are emissions from sources that will be owned or controlled by the owner of the proposed Gamsberg Smelter Project. Energy indirect, Scope 2, GHG emissions are emissions resulting from imported electricity consumed by the proposed Gamsberg Smelter Project. Other indirect GHG emissions, Scope 3, are the emissions (excluding energy indirect GHG emissions) that occur due to other project activities but occur at sources owned or controlled by another company.

In South Africa, the regulatory framework and the legal provisions related to climate change are still in the process of being developed and interpreted, as can be seen in the recent development surrounding the Thabametsi Case[1]. As the development of South African climate change laws and policies are still underway, there is minimal available guidance in the field of climate change impact assessments.

[1] *Earthlife Africa Johannesburg v Minister of Environmental Affairs and others* [2017] 2 All SA 519 (GP)

This Climate Change Impact Assessment report was informed by Section 24 of the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA), the Environmental Impact Assessment Regulations as published in the Government Gazette of 20 October 2014, as well as by the Thabametsi Power Station Court Case. It is noted that the NEMA regulations are designed to assess the impact of local pollutants, and do not sufficiently provide for the assessment of GHG emissions which have long-term[2] and global impacts but cannot be directly linked to local impacts. Where gaps in the South Africa legislation exists, this report was then guided by international best practice in the field of climate change assessments.

Both the social and environmental context that would be impacted on (directly and indirectly), have been considered in this study. This is especially relevant in terms of climate change, since climate change impacts are measured on a regional scale.

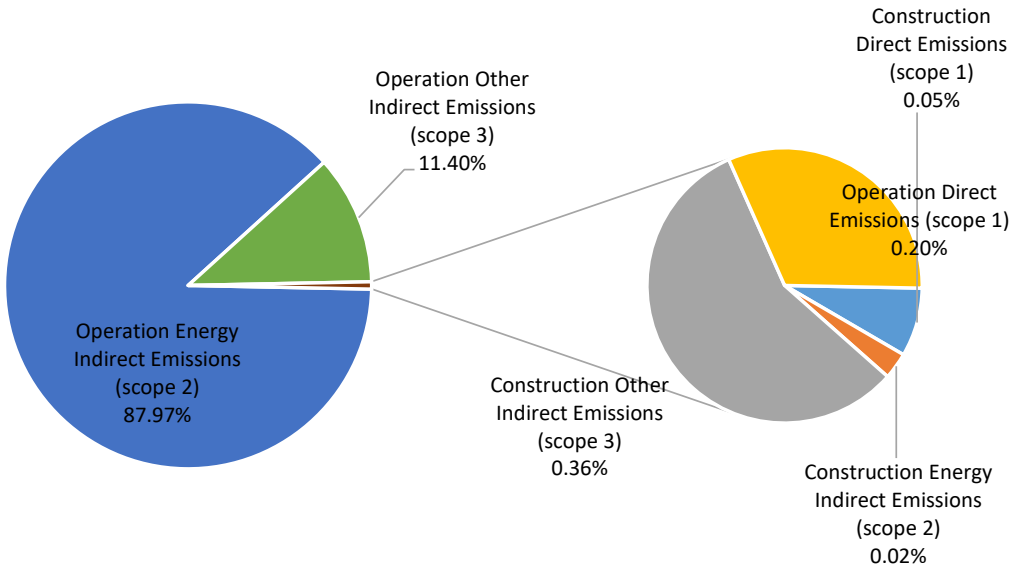
Based on the GHG inventory conducted within this assessment, the project's Scope 1, 2 and 3 emissions are summarised in the table below:

Summary of the GHG emissions calculated for the proposed Gamsberg Smelter Project

Emission categories	Total (construction and operations)	Construction (for whole construction period)	Operations (over the life of project)
Direct (Scope 1) Emissions	62 340 tCO_{2e}	12 598 tCO_{2e}	49 742 tCO_{2e}
Indirect (Scope 2) Emissions	21 636 859 tCO_{2e}	4 859 tCO_{2e}	21 632 000 tCO_{2e}
Other Indirect (Scope 3) Emissions	2 890 653 tCO_{2e}	88 486 tCO_{2e}	2 802 167 tCO_{2e}
Total Emissions	24 589 852 tCO_{2e}	105 942 tCO_{2e}	24 483 909 tCO_{2e}

The proposed Gamsberg Smelter Project is expected to generate approximately 62 340 tonnes of carbon dioxide equivalent (tCO_2e) of **direct emissions** over the proposed smelter's lifetime, which is approximately 0.3% of the total calculated emissions. The direct emissions are from the combustion of diesel and are considered to be within the direct control of the proposed Gamsberg Smelter Project (this pertains to stand-by generators and not routine consumption). The bulk (99.7%) of the proposed Gamsberg Smelter's lifetime emissions are, however, categorised as indirect emissions which arise during the operations phase, see figure below

[2] GHG emissions can remain in the atmosphere for hundreds of years.



Distribution of lifetime GHG emissions generated by the proposed Gamsberg Smelter Project

Emissions from the consumption of grid-based electricity (energy indirect emissions) during operations accounts for the majority (87.9%) of the project's lifetime emissions. The bulk of the other indirect emissions (scope 3) arise from fuel and energy related activities as a result of the large electricity consumption.

The proposed Gamsberg Smelter Project's calculated emissions inventory in terms of South Africa's remaining portion of the global carbon budget is presented in the following table.

The Gamsberg Smelter Project's emissions relative to South Africa's carbon budget

Category	Emissions	Percentage
South Africa's carbon budget	7 572 $MtCO_2e$	
Scope 1 and 2 emissions (project life)	21.7 $MtCO_2e$	0.29% of SA's carbon budget
Scope 1, 2 and 3 emissions (project life)	24.6 $MtCO_2e$	0.32% of SA's carbon budget

The impact of the proposed Gamsberg Smelter Project's GHG inventory is considered to be **high** due to the total project inventory being approximately 0.3% of South Africa's carbon budget. Details of the range of values to determine impact is provided in Section 2 of this report.

The proposed Gamsberg Smelter Project would impact on climate change through the inevitable generation of emissions, through both the direct and indirect emissions generated. It is estimated that the total direct (Scope 1) and energy indirect (Scope 2) emissions associated with the proposed Gamsberg Smelter Project will be approximately 13.5 million tCO_2e over its construction and operational lifetime. The upstream and downstream emissions associated with this project (Scope 3) within South Africa is 2 million tCO_2e.

Based on the methodology used to assess the impact of the proposed Gamsberg Smelter Project on climate change, the Gamsberg Smelter project has a high impact on climate change. This relates

predominantly to the substantial requirement and use of grid electricity. There are two mitigating issues to consider in this regard:

1. The use of zinc, both in terms of zinc ingots as well as the use of sulphuric acid in the copper smelting process, should this be required by a customer, contributes to the development of a low carbon economy. Zinc product plays an important role in enabling this transition as it supports the growth and development of renewable energy technologies; and
2. Although the emissions from the proposed Gamsberg Smelter Project are considered high in terms of the methodology used, direct emissions from this project will be in the range of internationally accepted values.

The majority of the emissions related to this project stem from the use of grid-based electricity in South Africa. South Africa currently has a high grid emission factor due to the electricity supply being predominantly coal-based. In this regard this study suggests that the project investigates opportunities related to the inclusion of renewable energy for its operations.

Due to the potential exacerbation of the various other social and environmental impacts of the proposed Gamsberg Smelter Project's activities as a result of climate change, we recommend that climate change and its associated risks and impacts should be considered for the following:

a) The Social and Labour Plan (SLP) – Climate change can significantly impact the socio-economic conditions under which the surrounding communities live. The SLP should therefore consider the impacts of climate change on its workforce, immediate local communities and its potential to support climate resilience in the local municipality;
b) The use of alternative energy supply sources, such as solar and wind, should be considered to offset the high energy use from Eskom, which is predominantly coal-based; and
c) Closure and Rehabilitation Plan – An extensive and ambitious rehabilitation plan must be developed which should be informed and guided by the biodiversity offsetting agreement and post-operational rehabilitation measures which should be implemented by the proposed Gamsberg Smelter Project owners. The closure plan and rehabilitation strategies must therefore consider climate change and climate modelling and the potential impacts thereof. These measures should make consistent reference to the predicted climate change impacts which are anticipated to affect the proposed Gamsberg Smelter Project areas and the possible adaptation measures proposed.

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ABBREVIATIONS

Abbreviation	Definition
CH_4	Methane
CO_2	Carbon dioxide
EIA	Environmental Impact Assessment
IPCC	Intergovernmental Panel on Climate Change
IRP	Integrated Resource Plan
ktpa	Kilo-Tonnes Per Annum
LTAS	Long Term Adaptation Scenarios
Mt	Million tonnes
$MtCO_2e$	Million tonnes of carbon dioxide equivalent
N_2O	Nitrous Oxide
NDC	Nationally Determined Contribution
NPC	National Planning Commission
RCP	Representative Concentration Pathway
SDA	Sectoral Decarbonization Approach
tCO_2e	Tonnes of carbon dioxide equivalent
WRI	World Resources Institute

Key Terms and Definitions[3,4]

Climate change	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 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).
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 (SF6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).
Climate change impacts	The consequences of realized 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, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.
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.
Climate resilience[5]	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.
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

[3] IPCC, 2014. Fifth Assessment Report of the IPCC, Annex 1: Glossary s.l.: s.n. Viewed 29 July 2019 https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_AnnexI_Glossary.pdf

[4] IPCC, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp

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

	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.
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.
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.
RCP 2.6	Pathway where radiative forcing peaks at approximately 2.6 W/m^2 before 2100 and then declines.
RCP 4.5	It is a stabilization scenario in which total radiative forcing is stabilized at approximately 4.5 W/m^2 shortly after 2100, without overshooting the long-run radiative forcing target level.
RCP 6.0	Stabilization without overshoot pathway to 6 W/m^2 at stabilization after 2100.
RCP 8.5	This RCP is characterized by increasing GHG emissions over time, representative of scenarios that lead to high GHG concentration levels. Radiative forcing reaches greater than 8.5 W/m^2 by 2100 and continues to rise for some amount of time.
Social vulnerability drivers[6]	Social vulnerability is defined as a dynamic state of societies comprising exposure, sensitivity and adaptive capacity. It is characterized 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.

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

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	Section 1.3
The expertise of that person to compile a specialist report including a curriculum vitae	Section 1.3
A declaration that the person is independent in a form as may be specified by the competent authority	Pg. ii
An indication of the scope of, and the purpose for which, the report was prepared	Section 1.2
An indication of the quality and age of base data used for the specialist report	Section 6
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 2
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 4
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 proposed Gamsberg Smelter Project.
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 2.3
A description of the findings and potential implications of such findings on the impact of the proposed activity or activities	Section 5 and 6
Any mitigation measures for inclusion in the EMPr	Section 7
Any conditions for inclusion in the environmental authorisation	

Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 7
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	Sections 8
A description of any consultation process that was undertaken during the course of 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

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DECLARATION OF INDEPENDENCE

The authors of this report do hereby declare their independence as consultants appointed by SLR Consulting to undertake a climate change assessment for the proposed Gamsberg Smelter Project. 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

Karien Erasmus

Marc Coetzee

Kenneth Slabbert

1 INTRODUCTION

Gamsberg Zinc Mine operation is owned and operated by Black Mountain Mining (Pty) Ltd, part of Vedanta Zinc International. Black Mountain Mining (Pty) Ltd is now proposing to construct a new zinc smelter and associated infrastructure at Gamsberg to produce 300 000 tpa special high grade zinc metal by processing 680 000 tpa of zinc concentrate (Gamsberg Smelter Project). As a by-product 450 000 tpa of pure sulphuric acid will be produced for both export and consumption within South Africa.

The Gamsberg Zinc Mine is currently operational and comprises the following, as per received project information and the Request for Proposal prepared by SLR Consulting South Africa (Pty) Ltd:

- Open pit zinc mine (currently 4 mtpa ore capacity, approved for up to 10 mpta);
- Existing concentrator plant (250 – 300 ktpa concentrate);
- Tailings storage facility for mining operations; and
- Employee housing.

Black Mountain Mining (Pty) Ltd intends to extend the scope of the Gamsberg Zinc Mine by developing a Smelter- Complex at the Gamsberg site to process the concentrate and produce refined zinc metal product. The proposed Gamsberg Smelter Complex is expected to have a capacity of 300 ktpa of finished zinc metal and will produce two main by-products as waste, namely 450 ktpa of sulphuric acid and 13 ktpa of manganese dioxide residue.

1.1 Study Objective

Promethium Carbon has been appointed to undertake a Climate Change Impact Assessment as part of the EIA process for the proposed Gamsberg Smelter Project. In accordance with the relevant regulations, an EIA process must be completed and an Environmental Authorization (EA) approved by the competent authority before the proposed project development can proceed. This involves assessing the project's prospective contribution to climate change through the emission of GHGs such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) as well as the emissions released from the proposed Gamsberg Smelter Project's value chain. The value chain extends from the various energy and metallurgy processes to the end users of the products. This assessment focuses on calculating the GHG emissions of the proposed Gamsberg Smelter Project, across its lifetime and investigating the consequent climate change impacts through the value chain. The assessment further evaluates the impact of climate change on the proposed Gamsberg Smelter Project by assessing climate change impacts on the core operations, value chain, social context and the environmental context, referred to as the broader network. The analysis is intended to establish whether or not the project has sufficiently considered the effects of climate change on its design and surrounding environment.

The analysis presented in this report is aligned with the principles of the National Environmental Management Act, 1998 (Act No 107 of 1998) (NEMA): Environmental Impact Assessment Regulations, 2014 as it seeks to provide the project developer with the best possible information to evaluate the project's environmental sustainability from a climate change perspective.

1.2 Scope of Work

The broad terms of reference and scope of work for this specialist climate change impact assessment include the following:

1. Conducting an impact assessment of the proposed Gamsberg Smelter Project:
    a) Considering its contribution to the South African national emissions inventory, the global GHG inventory, and the potential impacts of the proposed project on the onset of global anthropogenic climate change;
    b) Comparing the emissions associated with the value chain of the proposed Gamsberg Smelter Project against the current South African baseline with consideration of impacts on the future baseline; and
    c) Exploring the potential impacts of global climate change on the risks faced by the proposed Gamsberg Smelter Project and the project's broader network.
2. Assessing requirements for GHG emission management activities for the proposed Gamsberg Smelter Project's operations; and
3. Reviewing the GHG emissions mitigation options for the project.

1.3 Specialist Details

Promethium Carbon is a South African climate change and carbon advisory company based in Johannesburg. Our aim is to make a difference in climate change in Africa and our team of climate change professionals and technical experts assist businesses, ranging from small enterprises to multinational entities, on their journey towards a low carbon economy. We also assist governments and government institutions in planning for the imminent global carbon-constrained environment. We act as trusted advisors to our clients and have established ourselves as knowledge leaders in the climate space through our participation on various working groups and standards boards.

We have been active in the climate change and carbon management space since 2004. Our client base includes many of the international mining houses and industrial companies that are operating in, and from, South Africa.

Promethium Carbon's climate change impact studies typically 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 GHG inventories for over 60 entities and is proficient in applying the requirements of ISO/SANS 14064-1 and the GHG Protocol's accounting standards, as well as South Africa's GHG reporting guidelines. Promethium Carbon has also assisted around 40 clients to 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 client. We have also conducted climate change risk and vulnerability assessments as part of the Carbon Disclosure Project for over 20 clients, many whom have reported annually since 2008.

Robbie Louw is the founder and director of Promethium Carbon. He has over 15 years of experience in the climate change industry. His experience (36 years) includes research and development activities as well as project, operational and management responsibilities in the chemical, mining, minerals process and energy fields. Robbie is currently a member of The Southern African Institute of Mining and Metallurgy, 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 carbon footprinting. 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 risk assessments for various companies and projects; and
- Climate change scenario planning and analysis, particularly in terms of the recommendations of the Taskforce on Climate-related Financial Disclosure.

Karien Erasmus is a principal climate change advisor at Promethium Carbon and holds an Honours Degree in Sustainable Development. Her postgraduate qualifications include diplomas in: Project management, community development and mine closure and ecological rehabilitation. She has been involved in the sustainability and climate change industry for the past 14 years, working extensively in Africa and on strategic local projects such as the Gautrain and the Bus Rapid Transit system in Johannesburg. Karien joined Promethium Carbon in 2015 and utilises her developmental background to inform the social context of various climate change and low carbon development projects. Karien holds memberships with the Land Rehabilitation Society of Southern Africa and International Association for Impact Assessment. Over the past three years Karien has worked extensively within the mining sector. Karien's experience in climate change includes:

- Climate change risk and vulnerability assessments;
- Climate change impact assessments as part of the Environmental Authorisation (EA) process;
- Drafting Carbon Disclosure Project Climate Change and Water responses;
- Assessment of climate change and energy related regulations; and
- Developing the land, community and energy nexus concept which links land rehabilitation to community upliftment through sustainable energy projects.

Marc Coetzee is a climate change advisor at Promethium Carbon and holds a Master of Science Degree in Environmental Management. Marc joined Promethium Carbon in 2019 has been involved in the sustainability and climate change industry for the past 4 years, working within the following areas:

- Carbon footprint/GHG inventory development;
- Environmental liability and risk reviews;
- Climate Change Impact Assessments;
- Environmental due diligence;
- Asset retirement obligations;

- Sustainability framework development and governance assessments;
- Mainstreaming sustainability principles and practices into organizations; and
- Sustainability indicator assurance and readiness assessments in accordance to ISAE 3410 and ISAE 3000

Kenneth Slabbert *is a climate change advisor at Promethium Carbon and holds a Bachelor of Engineering in Mechanical Engineering. Kenneth joined Promethium Carbon in 2018 and has been working in the climate change industry for the past 2 years. Kenneth's experience in climate change includes:*

- Carbon footprint/GHG inventory development;
- Energy efficiency studies;
- Data analysis; and
- Climate Change Impact Assessments.

1.4 Global Context of climate change

Anthropogenic climate change as a global phenomenon is caused by the accumulated GHG emissions from man-made global emitting sources. Recently, CO_2 levels within the atmosphere surpassed 415 parts per million for the first time in recorded history[7]. This illustrates the impact of activities, such as the continued use of fossil fuel resources globally, and its contribution to climate change.

The global nature of climate change impacts is such that climate change effects cannot be attributed directly to a specific GHG emission. However, GHG emissions from any individual project or source is incorporated into a global receiving environment thereby having an impact on climate change indistinctly. Therefore, there is a collective responsibility to address the global challenge of climate change and each actor, such as the proposed Gamsberg Smelter Project, has an individual responsibility to minimise its own negative contribution to climate change.

The receiving environment for this project, in the context of climate change, is the global atmosphere. The duration of the impact of GHG emissions is considered to be long term as GHG emissions produced typically remain in the atmosphere for an extended period of time. In 2015 the world agreed in the Paris Agreement that the target to limit global warming should be a 2°C increase of average global temperature above the pre-industrial average temperature by the end of the century. The Intergovernmental Panel on Climate Change (IPCC) estimated in the 5th Assessment Report [16] that the global limit is to emit 2,900 gigatons of CO_2 above the pre-industrial levels by 2100. By 2012, a total of 1,890 gigatons of CO_2 had already been emitted. This leaves a remaining budget of 1,010 gigatons of CO_2 before the 2°C limit is breached. In the context of environmental impact assessments, this constitutes a **limited resource**. If the limit presented by this amount is exceeded, then the planet as a whole will suffer irreparable damage with dire consequences to the global society.

[7] USA Today, Carbon dioxide levels hit landmark at 415 ppm, highest in human history, available at: https://www.usatoday.com/story/news/world/2019/05/13/climate-change-co-2-levels-hit-415-parts-per-million-human-first/1186417001/.

The Paris Agreement, however, also states that the world should increase ambition and aim for a target of a 1.5°C temperature increase. The desire is targeted at reducing significant and far reaching impacts associated with climate change, such as; sea rise, desertification, ocean acidification, biodiversity loss and the increase in frequency and intensity of extreme weather events. In 2018, the IPCC estimated a remaining carbon budget of 580 gigatons CO_2 for a 50% probability of limiting warming to 1.5°C, and 420 gigatons CO_2 for a 66% probability (with medium confidence)[8].

1.5 Local Context of climate change

1.5.1 *South Africa's response to climate change*

South Africa's National Development Plan 2030 (NDP) is centred on reducing inequality and eliminating poverty by 2030. Climate change impacts and climate change mitigation are highlighted as critical issues within the NDP and are linked to inequality and poverty. As a result, a set of goals and actions to meet the country's environmental sustainability and resilience needs have been reported[9]:

- Achieving the peak, plateau and decline trajectory (PPD) for GHG emissions;
- Entrenching an economy-wide carbon price by 2030;
- Implementing zero emission building standards by 2030; and
- Achieving absolute reductions in the total volume of waste disposed to landfill each year.

South Africa's climate change response is also set out in the National Climate Change Response White Paper[10]. Within this document it is proposed that climate change be addressed through various interventions that build and sustain social, economic and environmental resilience by retaining a fair contribution to the global efforts to stabilise GHG concentrations in the atmosphere. South Africa's Nationally Determined Contribution (NDC) submitted in 2015 (as a response to the Paris Agreement) sets out the nation's emissions trajectory up to 2050. South Africa's emissions are expected to peak between 2020 and 2025, plateau for approximately a decade and decline in absolute terms thereafter (the 'peak, plateau and decline trajectory').

South Africa, as a developing nation, makes allowances to increase its emissions in the short-term, to foster economic growth and steadily transition towards a low carbon economy. However, the South African Government expresses through the White Paper and the Integrated Resource Plan that a shift to low-carbon electricity generation options will only be possible in the medium term, and not immediately. Therefore, South Africa is not limiting itself to specific emissions numbers but rather provides a peak, plateau and decline trajectory range from the year 2016 (reference point)

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[8] IPCC, 2018. IPCC, 2018: *Summary for Policymakers of IPCC Special Report on Global Warming of 1.5˚C approved by governments*, IPCC, Available at: https://www.ipcc.ch/2018/10/08/summary-for-policymakers-of-ipcc-special-report-on-global-warming-of-1-5c-approved-by-governments/

[9] Draft, South Africa's Low Emission Development Strategy 2050, Available at https://www.crediblecarbon.com/wp-content/uploads/2019/07/Draft-South-Africas-Low-Emission-Development-Strategy-2050.pdf

[10] National Climate Change Response White Paper, 2011. Available at https://www.gov.za/sites/default/files/gcis_document/201409/nationalclimatechangeresponsewhitepaper0.pdf

to 2050. The country's lower boundary peak, plateau and decline trajectory pledge is set at 398 Mt CO_2e and the upper boundary at 614 Mt CO_2e for the years 2025 to 2030. The Climate Change Bill (which is not yet finalised) will make provision for regular updates of this trajectory, through which it can be better placed within the context of the Paris Agreement and global trends.

The issue under consideration is the global shortfall in targets to reach the goal of limiting average temperatures to well below 2°C above pre-industrial levels. South Africa's NDC has been assessed as insufficient to meet a 2°C target. However, through the ratchet mechanism of the Paris Agreement, countries are able to accelerate efforts to achieve a 1.5°C, which allows countries such as South Africa to negotiate and determine how to achieve such a target. The ratchet mechanism requires countries to submit new NDCs every five years, outlining how much emissions they intend to reduce. Furthermore, it states that each submission should be more ambitious than the last. A ratcheted South African NDC (which could be categorised as a transitional risk) within the approximate period 2022-2025 could have an impact on the longevity of emission intensive projects.

In addition to the NDC, the base case of South Africa's draft updated Integrated Resource Plan (IRP)[11] incorporates the CO_2 emissions constraints as guided by the country's peak, plateau and decline trajectory. The IRP applies the moderate decline annual constraints as an instrument to reduce national emissions, which is in line with government policy to reduce GHG emissions. Government's policy might change in the future, as per the developments of the Department of Environment, Forestry and Fisheries (DEFF) mitigation system and proposed Climate Change Act. A process is currently being undertaken by the National Planning Commission (NPC) to develop a common vision for the country in 2050. As developing countries will suffer the most from the negative impacts of climate change as a result of a collective failure to limit global emissions, developed countries must take the lead in reducing emissions.

1.5.2 *South Africa's carbon budget*

South Africa's share of this global budget must be seen in the context of the global carbon budget of 1,010 gigatons of CO_2, as described above. In order to make a reasonable allocation of the country's fair share to this budget, the global budget was calculated on a per capita basis. The national population figure for South Africa is 58 million people[12]. If this is taken as a percentage of the global population of 7.7 billion people[13], then South Africa's carbon budget is approximately 7,572 Mt CO_2e. The evaluation of the impact of the proposed Gamsberg Smelter Project on this **limited resource** will therefore be done by considering its contribution to South Africa consuming its carbon budget.

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[11] Department of Energy, 2016. Integrated Resource Plan Update Assumptions, Base Case Results and Observations [Online]., Pretoria: Department of Energy.

[12] Stats SA, 2018. Mid-year population estimates 2018. Available at http://www.statssa.gov.za/?p=11341

[13] Worldometers, 2019. Current world population. Available at http://www.worldometers.info/world-population/

Despite the global and national commitment to limiting the global temperature increase to 2°C, the NDCs of all countries combined (in 2017) cover only approximately one-third of the emission reductions needed to achieve this goal[14]. Therefore, there will be significant climate change impacts affecting South Africa, and thus the proposed Gamsberg Smelter Project, regardless of whether the global community implements the NDCs. While the impact of the proposed Gamsberg Smelter Project on global climate change may be small, the impacts of climate change on the Gamsberg Smelter Project could potentially be large.

1.6 Observed Trends and Projected Climate Change

1.6.1 *National overview*

The impacts of climate change on South Africa have been summarised in the then Department of Environmental Affairs' *Long Term Adaptation Scenarios* (LTAS) study[15] in 2013. However, significant progress has been made in South Africa since the LTAS in terms of the local generation of detailed regional climate futures for the country. The most recent modelling was conducted for South Africa's *Third National Communication[16].*

The past forty years have shown that for South Africa there has been an increase in intensity and frequency of hydro-metrological hazards such as storms, floods, wildfires, droughts and extreme temperatures and it is likely that the frequency of these events will continue to increase in the years to come[17]. The IPCC found in its fifth assessment report that it is likely that land temperatures over Africa will rise faster than the global land average, particularly in the more arid regions, and that the rate of increase in minimum temperatures will exceed that of maximum temperatures[18]. This indicates that in a world of more than 2°C average temperature change, South Africa could experience changes of over 3°C.

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[14] UNEP (2017). *The Emissions Gap Report 2017*. United Nations Environment Programme (UNEP), Nairobi

[15] DEA, 2013. Long-Term Adaptation Scenarios Flagship Research Programme for South Africa. Climate Trends and Scenarios for South Africa., Pretoria.: Department of Environmental Affairs.

[16] DEA, 2017a. South Africa's Third National Communication under the United Nations Framework Convention on Climate Change, Pretoria: Department of Environmental Affairs.

[17] UN ESA (United Nations Department of Economic and Social Affairs, Population Division). 2014. World Urbanization Prospects: The 2014 Revision, custom data acquired via website. [Online] Available at: https://esa.un.org/unpd/wup/DataQuery.

[18] IPCC, 2014. Fifth Assessment Report of the IPCC, s.l.: s.n.

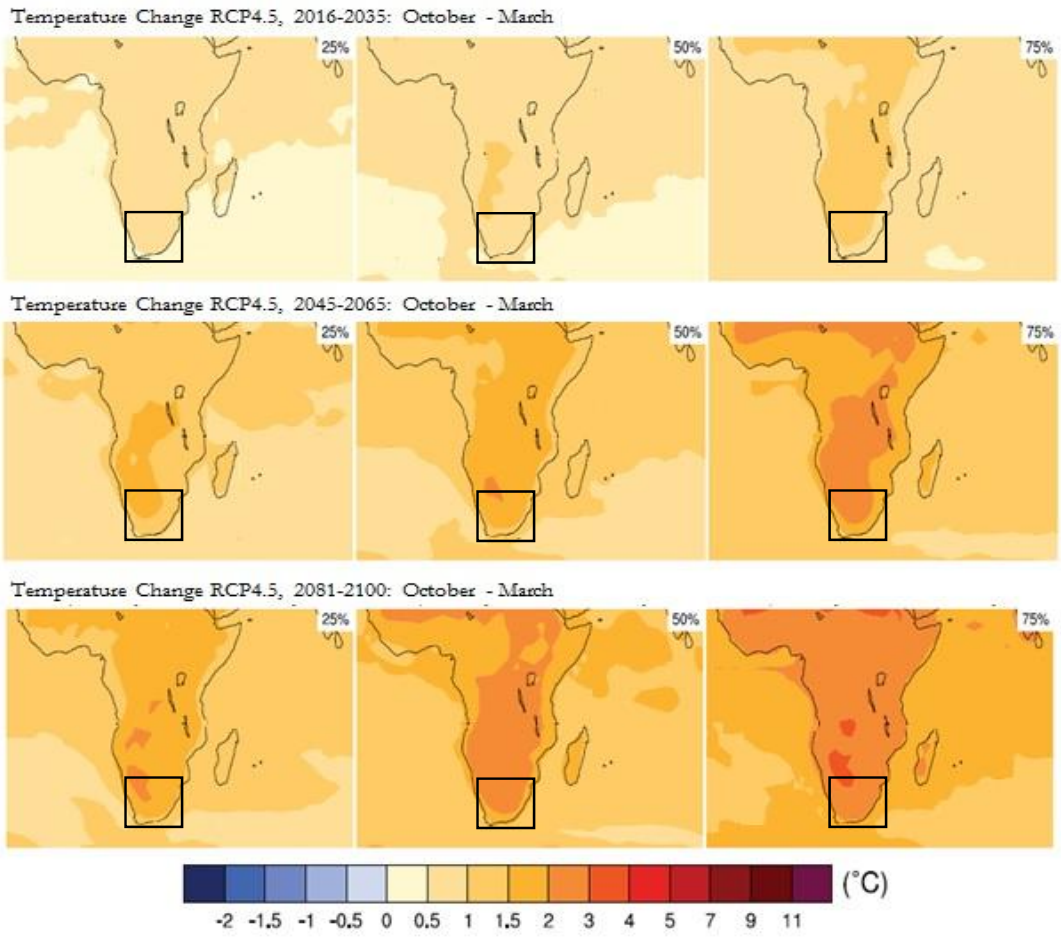

Figure 1: Projected Southern African temperature change under RCP4.5[19]

For the far-future period of 2080-2099, temperature increases of more than 4°C are likely over the entire South African interior, with increases of more than 6°C plausible over large parts of the western, central and northern parts. Such increases will also be associated with drastic increases in the number of heat-wave days and very hot days, with potentially devastating impacts on agriculture, water security, biodiversity and human health.

From below[20] it is evident that there is a projected decrease in precipitation during the wet season (October to March) towards the year 2100 projected for Southern Africa. Sustained warming and increasing variability in rainfall over the short term (next decade) will have increasingly adverse effects on key sectors of South Africa's economy in the absence of effective adaptation responses. Early impacts will largely be felt by the poor and vulnerable groups in society. These social groups are both more exposed and more sensitive to fluctuations in weather patterns and climatic events such as droughts and floods. In addition, poverty and a lack of infrastructure or service provision

19 DEA, 2017a. South Africa's Third National Communication under the United Nations Framework Convention on Climate Change, Pretoria: Department of Environmental Affairs.

20 DEA, 2017a. South Africa's Third National Communication under the United Nations Framework Convention on Climate Change, Pretoria: Department of Environmental Affairs.

erodes the adaptive capacity of these communities to climate change, rendering them increasingly vulnerable.

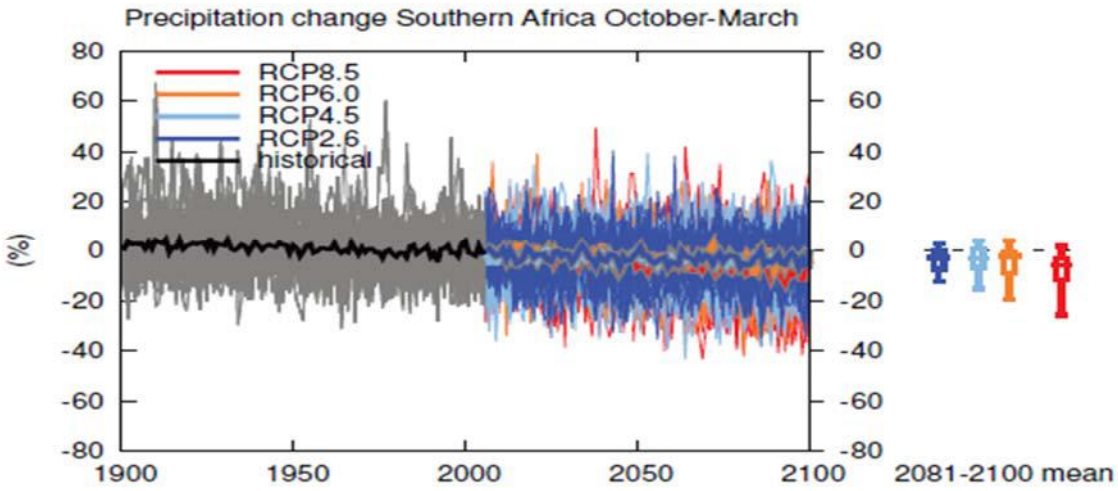

Figure 2: Projected global surface temperature change under different emissions scenarios[21]

The following sections consider climate on a provincial level, as relevant to the proposed Gamsberg Smelter Project.

1.6.2 *Provincial overview*

The Northern Cape Province is located in the north-western region of the country, characterised by a desert to semi-desert climate. The region experiences summer rainfalls (50 - 400mm/year), except for the narrow western coastal strip, which receives winter rainfall. Aggeneys falls within a transition zone which experiences both summer and winter rainfall. The eastern part of the province is also likely to experience thunderstorms in addition to rainfall. Average summer maximum daytime temperatures range between 34°C and 40°C and at times above, and winter daytime temperatures are mild although night temperatures can drop below 0°C[22].

Future temperatures could increase by an average of 1 - 4°C for the period 2020-2050, while the number of hot days annually may rise by up to 92 days in the far northern parts of the province. Such increases are associated with further increases in the number of heat-waves and fire danger days. This will increase the risk of fire and heat stress especially for people working outside and exposed to direct sunlight. Furthermore, rising temperatures will increase the demand for greater cooling within buildings and for equipment and thereby increase electricity consumption.

Climate change impacts on rainfall on the other hand show more uncertainty. The IPCC Special Report on the impacts of global warming indicate that Southern Africa is generally expected to become hotter and drier[23]. Current trends further indicate that rainfall in the future will be more

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21 DEA, 2017a. South Africa's Third National Communication under the United Nations Framework Convention on Climate Change, Pretoria: Department of Environmental Affairs.

22 NM Envirotech Solutions. 2016. Climate change status quo for the Northern Cape Province. NM Envirotech Solutions, Centurion, South Africa.

23 IPCC, 2018: Global Warming of 1.5°C.An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global GHG emission pathways, in the context of strengthening

variable, with predictions indicating less rainfall in the west with possible increases in rainfall for the eastern parts of the province. Additionally, rainfall events are expected to be more intense, meaning that the amount of water falling will occur over a shorter timeframe. Predictions further indicate an increase in evaporation of between 7% and 12% over the province. The combination of less rainfall, increased temperature and increased evaporation rates can result in less available surface water leading to drought conditions.

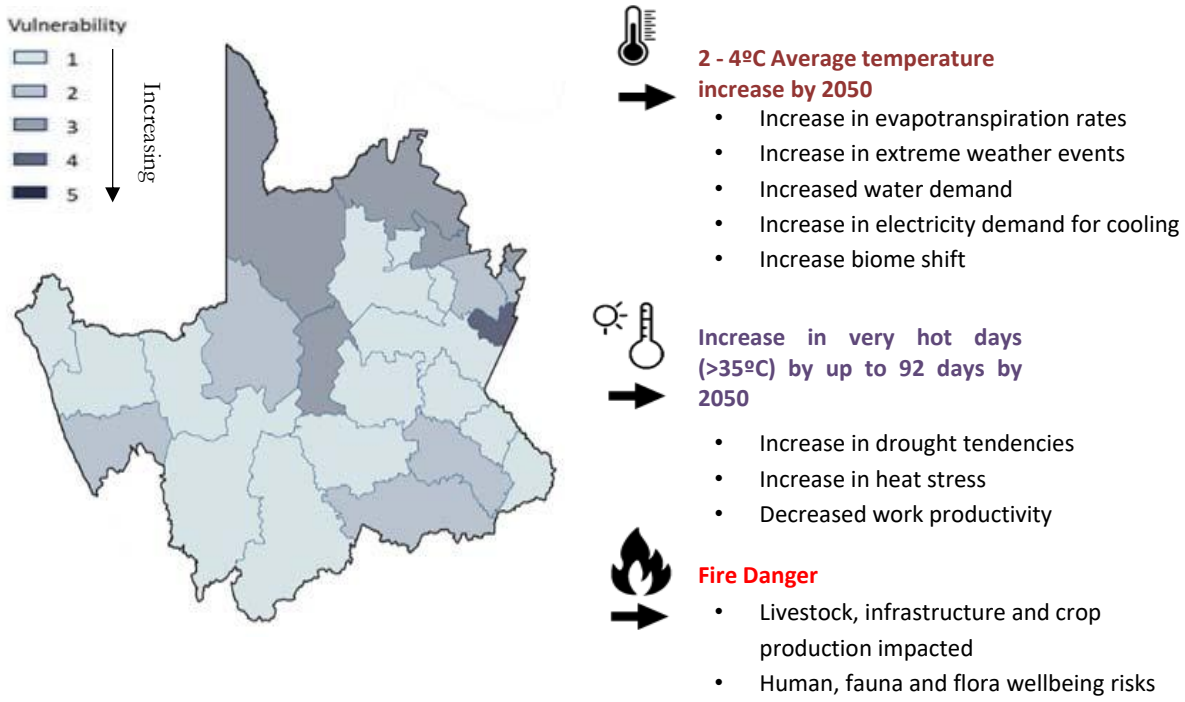

Figure 3: Climate change impacts in the Northern Cape[24]

The most significant projected climate change impacts relevant to the Northern Cape relate to increases in annual average temperatures, increases in the number of very hot days (>35ºC), water scarcity and biodiversity loss[25,26].

These risks relate to proposed Gamsberg Smelter Project in the following ways:

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the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.

[24] Infographic developed by Promethium Carbon

[25] Mambo, J. and Murambadoro, M. 2017. Municipal vulnerability to climate change. Pp 112-120 in Mambo, J. and Faccer, K., editors. South African risk and vulnerability atlas: understanding the social and environmental implications of global change. Department of Science and Technology, Pretoria, South Africa, and CSIR, Pretoria, South Africa.

[26] DENC. 2016. Vulnerability Assessment Report for the Northern Cape. Department of Environment, Nature Conservation, Kimberly, South Africa.

- Decreasing water availability may negatively affect the proposed Gamsberg Smelter Project's direct operations as well as the upstream and downstream value chain;
- Damages to infrastructure as a result of flash flooding events could disrupt operations, transport of goods and lead to increased risk of injury;
- Disruption to commerce, critical infrastructure and developments, transport systems and traffic by extreme rainfall events and flooding may impact on the proposed Gamsberg Smelter Project's ability to operate;
- Increased number of power outages, water supply and transport disruptions;
- Increased risk of infectious, respiratory and skin diseases, water- and food-borne diseases;
- Labour productivity decrease due to excessive heat exposure;
- Health of employees which may be compromised due to rising food insecurity and an increased number of casualties as a result of heat effects; and

1.7 Other potential climate change dimensions relevant to the Gamsberg Smelter Project

Other potential climate change risks are those that relate to climate change but cannot be classified as physical or regulatory risks. These risks can include:

- Reputational risk, especially concerning negative perceptions of the general public or investors;
- Changes in consumer behaviour relating to customer preferences for products/services;
- Induced changes in human and cultural environments (for example, migration and cultural changes);
- Fluctuating socio-economic conditions; and
- Increasing humanitarian demands, as climate change impacts are experienced.

South Africa, and the Northern Cape Province in particular, have an economically divided society due to a number of socio-economic disparities. This has resulted in local communities having greater exposure to the impacts of climate change and thus are more vulnerable. This may pose a risk to industrial developments such as the proposed Gamsberg Smelter Project through increased humanitarian demands.

1.8 Description of Activities undertaken as part of the Climate Change Impact Assessment

Currently there is no specific climate change related regulations in terms of EIA specialist study requirements. However, the Thabametsi Case is South Africa's **legal precedent** pertaining to climate change. Thabametsi's EA was appealed by Earthlife (Applicant) on the basis that the Chief Director had failed to consider the climate change impacts of the power station. Earthlife maintained that the Department of Environmental Affairs was obliged to consider the climate change impacts **before** granting an EA and that it failed to do so. The judgment states that a Climate Change Impact Assessment (CCIA) must follow a two-pronged approach to assess the:

1. Impact of climate change on the project (project vulnerability); and
2. Impact of the project on climate change.

Within the context of the Thabametsi Case judgement and the approach determined in this judgement, Promethium Carbon determined both the proposed Gamsberg Smelter Project's impact on climate change as well as the project's vulnerability to climate change. This is described below.

The process used to calculate the impact of the proposed Gamsberg Smelter Project on climate change (carbon footprint) follows the below steps:

- Boundaries of the analysis are identified;
- GHG sources inside the boundary are identified;
- Quantification method is established; and
- GHG emissions inventory is calculated.

Through these activities the relevant carbon emissions are determined and the contribution to climate change identified.

The impact of climate change on the proposed Gamsberg Smelter Project is informed by;

- The nature of climate change applicable to the area in which the proposed Gamsberg Smelter Project will be situated;
- Applicable timeframes with regards to both the project and long-term climate impacts; and
- Risks and vulnerabilities applicable to the proposed Gamsberg Smelter Project and the areas in which it will operate.

Climate change could pose a significant threat to processes at the proposed Gamsberg Smelter Project in that it can disrupt key areas such as the core operations, the natural environment, including biodiversity, the value chain, and have impacts that directly affect the social context of the area. Therefore, climate change impacts within these key areas are focused on as described below:

1. **Core operations** - The core operations relate to the proposed Gamsberg Smelter Project's site activities taking place which are essential to operations of the facility. These activities are centred on processes related to mineral beneficiation. The impacts of climate change on these site operations will be considered in this regard;
2. **Value chain** – The value chain relates to the goods and services the proposed Gamsberg Smelter Project requires to operate as well as downstream emissions related to the transport of the product and the processing of the product;
3. **Social environment -** The social context as part of this assessment refers to communities/settlements (both urban and rural) that would be impacted, both directly and indirectly, by climate change. The social context is important because it contributes in the form of labour and service provision. In addition, the social context could also impact operations at the proposed Gamsberg Smelter Project from a social volatility and vulnerability perspective. Social tensions, safety and poverty/inequality could, therefore, affect productivity and could have operational impacts on the proposed Gamsberg Smelter Project; and
4. **Natural environment** – The natural environment relates to natural assets and environmental ecosystems that deliver valuable services to people, such as water and climate regulation, soil formation, biodiversity and disaster risk reduction. The natural environment plays an important

role in terms of supplying key ecological services and resources to the proposed Gamsberg Smelter Project.

2 APPROACH AND METHODOLOGY

2.1 Impacts of the proposed Gamsberg Smelter Project on Climate Change

The following subsections outline the methodology used to assess the impacts the proposed Gamsberg Smelter Project development will have on the environment in terms of GHG emissions. The results of the carbon footprint calculations and the assessment of its environmental impacts are presented in section 5 of this report.

2.1.1 *Greenhouse gas emissions estimation methodology*

The GHG emissions of the proposed Gamsberg Smelter Project are calculated using the following standard:

- SANS/ISO 14064 Part 1 (2006);
- 2006 IPCC Guidelines for National GHG Inventories;
- The GHG Protocol, which builds on ISO14064;
- The Technical Guidelines for Monitoring, Reporting, Verification and Validation of GHG Emissions by Industry (Technical Guideline), as forming part of the National GHG Emission Reporting Regulations; and
- IFC's Performance Standard 3.

It should be noted that, in 2018, the ISO 14064-1 standard was updated. However, this standard was not used in the compilation of this report, since the ISO14064-1:2018 has not yet been accepted by the South Africa National Standards (SANS)[27]. The anticipated changes are summarised in the comparison in Table 1 below.

[27] SABS, 2019. List of Published Standards, [Online] Available at: https://www.sabs.co.za/Business_Units/Standards_SA/Controls/Published_Standards/PS207.PDF

Table 1: Comparison of the new ISO 14064-1:2018 Standard to the existing GHG Protocol[28].

ISO 14064:2018		GHG Protocol	
ISO14064 Category	Description	GHG Protocol Category	Description
1	Direct GHG emissions and removals	Scope 1	Direct emissions
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 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
		Scope 3, category 8	Upstream Leased Assets
		Scope 3, category 13	Downstream Leased Assets
		Scope 3, category 14	Franchises
		Scope 3, category 15	Investments

The boundaries for this climate change impact analysis for the proposed Gamsberg Smelter Project are set in terms of SANS 14064 Part 1. The emissions calculations for the proposed Gamsberg Smelter Project are applied based on the control approach and therefore the emissions calculated in this report consider the emissions from activities in the proposed Gamsberg Smelter Project. The setting of operational boundaries is a two-step process:

[28] Promethium Carbon notes from ISO/GHG Protocol feedback session.

Step 1: Identification of the emissions associated with the proposed Gamsberg Smelter Project operation; and

Step 2: Classification of the emissions into three categories. These three categories are defined according to *ISO 14064 Part 1* as direct GHG emissions, energy indirect GHG emissions, and other indirect GHG emissions, but are commonly referred to by The GHG Protocol as Scope 1, Scope 2, and Scope 3 emissions.

In terms of ISO 14064, emissions are classified as:

- **Scope 1 emissions**: Direct GHG emissions occur from sources that are owned or controlled by a company. Examples include emissions from combustion in boilers and furnaces;
- **Scope 2 emissions**: Indirect GHG emissions from the generation of purchased electricity consumed by a company; and
- **Scope 3 emissions**: Other indirect GHG emission that occur as a result of the activities of the company.

Note that the analysis does not include the calculation of the construction and operational GHG emissions of the proposed Gamsberg Smelter Project alternatives, as the assessment focussed on project description as presented in Scoping Report, the RFP and the data provided on the request for information provided at the time of this impact assessment.

Detailed information is not available for the decommissioning phase. Compared to the operational emissions, it is expected that the decommissioning phase emissions of the proposed Gamsberg Smelter Project will be insignificant. Nevertheless, it is important that the impacts of climate change are considered in the decommissioning and rehabilitation plans.

2.1.2 *International best practice*

As South African laws, mostly considered under the umbrella of the National Environmental Management Act do not provide adequate information and guidelines for the development of the required climate change impact assessments, this report makes use of globally accepted international best practice, including:

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

The abovementioned documents were used to develop a rating system (indicated in Table 2) to which the current project is benchmarked. This enables us to adequately assess climate change impacts in light of available baselines and relevant information.

2.1.3 *Emission factors*

It is important that the emission factors used in carbon footprint calculations are appropriate for the local context and relevant to the technology being assessed. Local emission factors, such as the national grid emission factor, have been sourced from the reports of Eskom as it is the main electricity generator of the country. Other recognised emission factors have also been sourced from South Africa's *Technical Guidelines for Monitoring, Reporting and Verification of GHG Emission by Industry*[29]. These emissions factors are presented in tonnes of carbon dioxide equivalent (tonne CO_2e) and consider the global warming potential of all emitted GHGs including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The latest emission factors from the UK's Department of Environment, Food and Rural Affairs (2019) data sets were used where local or domestically approved emission factors were not available.

The assessment further focuses on the emission data for the operational and construction phases of the proposed Gamsberg Smelter Project. The emissions associated with the decommissioning phases are not anticipated to be significant in comparison to the emissions associated with the operational phase.

2.1.4 *Environmental impacts of GHG emissions*

The environmental impact assessment reporting requirements listed below set out the criteria to describe and assess local environmental impacts. However, climate change is a global phenomenon thus the criteria are only partially applicable to the assessment of the impacts of GHG emissions on climate change. Despite this, these criteria are currently the best tool for a climate change impact analysis and will be used in this assessment.

Table 2: 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) or regional. 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 duration is always long term, and thus a 5 is allocated to all projects that contribute to global anthropogenic climate change.

[29] Department of Environmental Affairs, 2017. Technical Guidelines for Monitoring Reporting and Verification of GHG Emissions by Industry, South Africa

<table>
<tr><td>Magnitude (M)</td><td>An indication of the consequences of the effect quantified as high, medium or low. The National Environmental Management Act and related EIA regulations were developed to describe and assess environmental impacts, however GHG emissions that have a global impact has yet to be described. For this reason, a materiality threshold was defined by the specialist to inform the magnitude determination of the project. The methodology proposed to determine magnitude is based on two fundamental principles: 1) The remaining South African Carbon budget based on the most recent publically available information and 2) the scale of emissions in terms of contributing to the use of this budget, considering South Africa’s NDC, our PPD trajectory and the commitments/recommendations set out in the Paris Agreement and increasing pressure to achieve a 1,5°C target. South Africa’s carbon budget is described in Section 1.5.2 of this report. The following impact ratings have been identified as a means of benchmarking GHG inventories over the lifetime of the specific activities related to emissions that occur within the boundaries of South Africa.
Table 3: GHG emissions impact rating
<table>
<tr><th></th><th>GHG inventory</th><th>% of South African carbon budget</th></tr>
<tr><td>South Africa's carbon budget based on the proportion of the local population</td><td>7,572 MtCO_2e</td><td>100%</td></tr>
<tr><td><u>Low</u> impact by project – emissions up to:</td><td>10,000 tCO_2e</td><td>0.00013%</td></tr>
<tr><td><u>Medium</u> impact by project – emissions up to:</td><td>1,000,000 tCO_2e</td><td>0.013%</td></tr>
<tr><td><u>High</u> impact by project – emissions up to:</td><td>10,000,000 tCO_2e</td><td>0.13%</td></tr>
</table></td></tr>
<tr><td>Probability (P)</td><td>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[30]. Thus, a value of 5 is allocated to all projects that contribute to global anthropogenic climate change.</td></tr>
<tr><td>Significance (S)</td><td>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).</td></tr>
</table>

The impact can be described as positive, negative or neutral. Additional details are provided in this report on the degree to which this impact can be reversed or mitigated. Details regarding the extent to which the impact may cause irreplaceable loss of resources are also provided.

[30] 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.

2.2 Impacts of Climate Change on the proposed Gamsberg Smelter Project

The impacts of climate change on the proposed Gamsberg Smelter Project are assessed for two reasons:

1. To establish whether or not the proposed Gamsberg Smelter Project has sufficiently considered the effects of climate change on its design. This is important as the EIA considers the impact of the proposed Gamsberg Smelter Project on the environment, but if the environment is due to change as a result of climate change during the life of the project then this should be considered in the EIA; and
2. The impact of climate change on the proposed Gamsberg Smelter Project is considered as it relates to the guidance provided by the judgement in the Thabametsi Case[31].

In South Africa, the regulatory framework and the legal provisions related to climate change are still in the process of being developed and interpreted, as can be seen in the recent development surrounding the Thabametsi Case[32].

As the development of South African climate change laws and policies are still underway, there is minimal available guidance in the field of climate change impact assessments. In light of the minimal guidance available the specialist considered existing environmental legislation and best practice guidelines to inform the study's methodological approach.

This assessment report is informed by Section 24 of the *NEMA,* the *Impact Assessment Regulations* as published in the Government Gazette of 20 October 2014, as well as by the Thabametsi Case. It is noted that the *NEMA* regulations are designed to assess the impact of local pollutants, and do not sufficiently provide for the assessment of GHG emissions which have long-term[33] and global impact but cannot be directly linked to local impacts. Where gaps in the South Africa legislation exists, this report was then guided by international best practice in the field of climate change assessments.

One of the primary international resources that is available to assess the impact of climate change on mining operations is the International Council on Mining and Metals' guidance document: "*Adapting to a changing climate: implications for the mining and metals industry*"[34]. The publication stipulates that, in principle, the core operations, the value chain, and the broader network (which we have expanded into the social and environmental networks) associated with the proposed Gamsberg Smelter Project must be considered when assessing the climate change impacts of this proposed operation. Both the social and environmental context that would be impacted (directly and indirectly), have been considered in this study. This is especially relevant in terms of climate change since climate change impacts are measured on a regional scale.

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[31] High Court of South Africa judgement on Thabametsi power project Available at https://cer.org.za/wp-content/uploads/2017/03/Judgment-Earthlife-Thabametsi-Final-06-03-2017.pdf

[32] Earthlife Africa Johannesburg v Minister of Environmental Affairs and others [2017] 2 All SA 519 (GP)

[33] GHG emissions can remain in the atmosphere for thousands of years.

[34] International Council on Mining and Minerals, 2013, Adapting to a changing climate: implications for the mining and metals industry. ICMM

The potential impact of climate change on the proposed Gamsberg Smelter Project is analysed through a climate change vulnerability assessment related to both the construction and operational phases. Vulnerability relates to the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes weather events. Vulnerability is a function of a number of variables, including the character, magnitude and rate of climate change, the variation to which a system is exposed, its sensitivity and its adaptive capacity (Figure 4)[35].

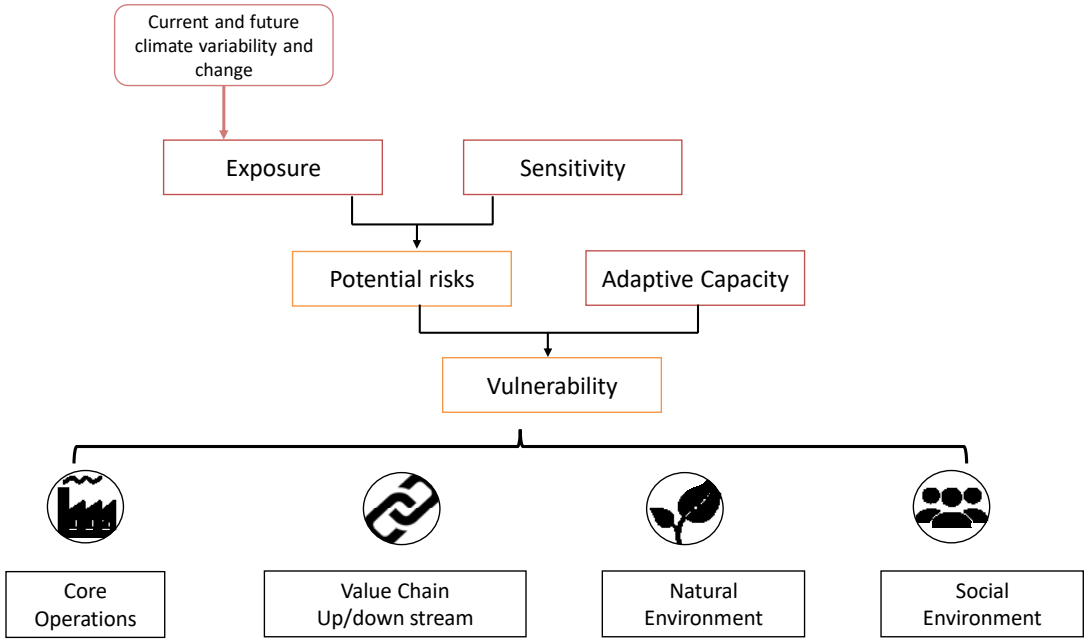


Figure 4: Vulnerability assessment process[35]

The assessment considered risks from the perspective of climate change impacts on temperature, water, biodiversity, transitional risks and the social context and how this influences the proposed Gamsberg Smelter Project's core operations, value chain and the broader network. In terms of this climate change impact assessment, Representative Concentration Pathways (RCP) 4.5 (low mitigation scenario) and RCP 8.5 (business as usual scenario) scenarios were selected[36]. Focus was placed on these two scenarios as the business as usual scenario gives a good indication of how climate change would precipitate per the current conditions. RCP 4.5 was selected as an intermediate scenario with a conservative representation of limited efforts to reduce global average temperatures. This is more consistent with most national policies that aim to effect change within developmental constraints.

[35] Parry, M., Canziani, O. & (eds.), e. a., 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, s.l.: s.n.

[36] The RCP 2.6 scenario was not considered as a request from the Department of Environment, Forestry and Fisheries. RCP 2.6 is indicative of a high mitigation scenario which requires a major turnaround in terms of climate policies and action to limit emissions within the next few years.

The climate change impact assessment typically focusses on two key factors, temperature and precipitation (Figure 5). These two factors are paramount in determining holistic climate change impacts on the proposed Gamsberg Smelter Project development due to the fact that these aspects have various direct and indirect impacts of significant consequence. As a result, the climate change impact assessment considers these two principle climate aspects, under RCP 4.5 and RCP 8.5 scenarios.

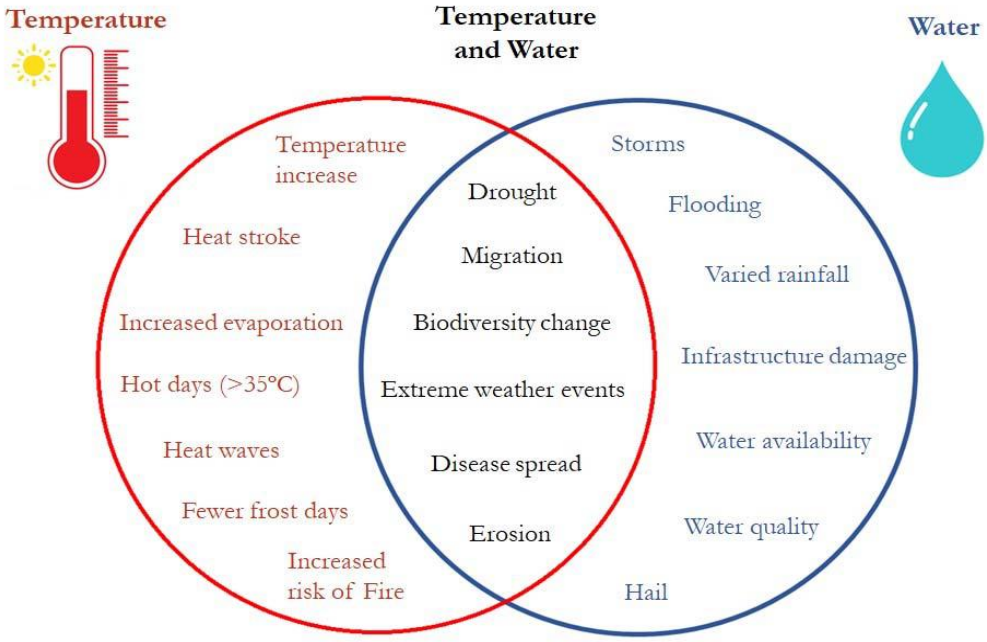


Figure 5: Possible temperature and water related climate change impacts

The assessment also considers the recent recommendations by the Task Force on Climate-Related Financial Disclosures (TCFD) to report climate change risks according to two main categories:

- **Transition risks:** Transitioning to a lower-carbon economy may entail extensive policy, legal, technology and market changes to address mitigation and adaptation requirements related to climate change. Depending on the nature, speed, and focus of these changes, transition risks may pose varying levels of financial and reputational risk for the proposed Gamsberg Smelter Project; and
- **Physical risks**: Physical climate change risks can be event driven (acute) or longer-term shifts (chronic) in climate patterns. Physical risks may have financial implications for the proposed Gamsberg Smelter Project, such as interruption of operations, direct damage to assets and indirect impacts from supply chain disruption.

2.3 Limitations and Assumptions

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 levels of uncertainty at much finer scales. 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[37]. This is particularly relevant for rainfall projections where different climate change models are used. However, climate change science is advancing at a rapid pace with refinements to modelling continuously being made. As such the latest climate change scenarios and projections were used in this climate change assessment.

3 APPLICABLE LEGAL REQUIREMENTS

The NEMA and the associated EIA Regulations, 2014 requires an EIA to include an assessment of climate change impacts for all projects with potentially serious climate change impacts before the competent authority (CA) (the CA for this project is the DMRE) can grant authorisation of the EIA.

As described earlier, the Thabametsi Case is South Africa's legal precedent pertaining to climate change with the court judgment stating that an assessment of climate change impacts must consider both the impact of climate change on the project and the impact of the project on climate change. Therefore, the assessment of climate change impacts must not only quantify the project's GHG (GHG) emissions but also include an assessment of the broader climate change impacts (such as drought and health impacts related to changing climate), and how the project would make them worse. Furthermore, the assessment must consider the extent to which the viability of the project itself will be affected by climate change impacts (extreme weather events, water scarcity, and increased temperatures). As such the competent authority must determine which, if any, measures are required to reduce emissions, and to ensure the resilience of the project and the surrounding environment to those impacts.

4 DESCRIPTION OF THE RECEIVING ENVIRONMENT

As described in Section 1 of this report, the receiving environment for the proposed Gamsberg Smelter Project, in the context of climate change, is the global atmosphere. Yet, the impacts of climate change affect various environments as a result of GHG emissions released into the global atmosphere. A description of these environments are illustrated below.

4.1.1 *Location and Climate*

The proposed Gamsberg Smelter Project is located in the Khâi-Ma Local Municipality within the Namakwa District Municipality of the Northern Cape Province of South Africa. The proposed Gamsberg Smelter Project is located at the Gamsberg Zinc Mine, between the towns of Aggeneys and Pofadder, approximately 120 km east of Springbok along the N14 (Figure 6). The areas surrounding the site are comprised of relatively flat plains, various inselberg with farmsteads characterised by sparse vegetation and low density livestock that are supported by groundwater from boreholes[38].

[37] 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.

[38] ERM, 2013. Geohydrological Specialist Report, Gamseberg Mine ESIA and EMP.

Approximate location of Gamsberg Smelter Project

Figure 6: Namakwa District Municipality[39]

The Khâi-Ma Municipality experiences very low mean annual precipitation of approximately 92 mm[40]. The majority of the rainfall occurs in the summer months from January to June. Due to the low annual rainfall, flooding is rare. However, due to the arid nature of the area, flash floods occur easily if there is a large downpour as the ground is hard and water rushes off along preferential pathways. The only areas susceptible to flooding occur along the Orange River approximately 33km north of the site. Drought, on the other hand, is more common particularly in the eastern areas of the Khâi-Ma Municipality which is more drought-prone. The Human Settlements, Water and Sanitation Minister and the Northern Cape Premier have recently agreed that the province should be declared a disaster area due to the debilitating drought conditions[41].

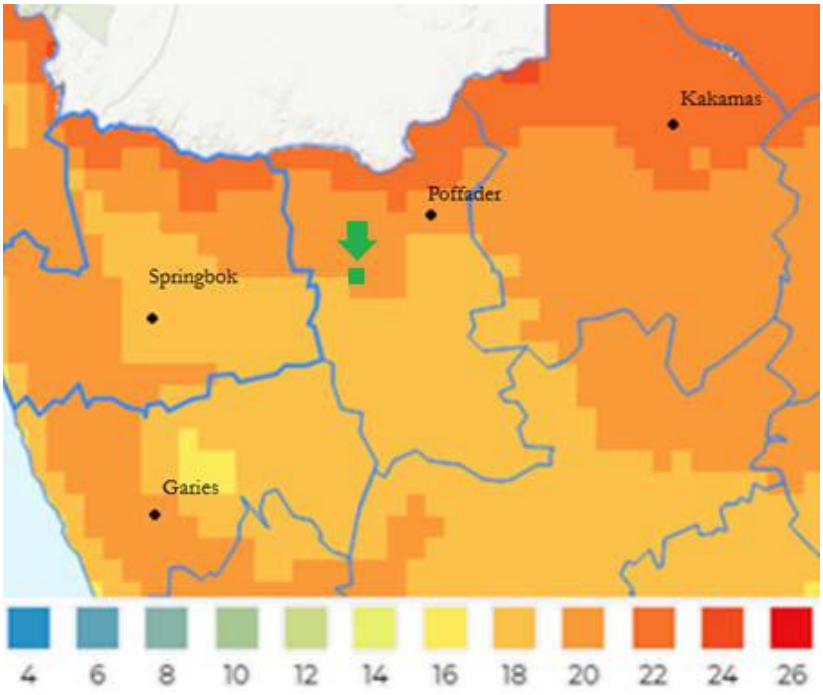
Maximum temperatures range from 35˚C to 39˚C with minimum temperatures of -1˚C to 13˚C and a mean annual temperature of approximately 20˚C. The area experiences between 30 and 45 very hot days (temperate exceeds 35˚C) and is characterised as a hyper-arid environment with potential

[39] Municipalities of South Africa Website available at https://municipalities.co.za/map/1170/khai-ma-local-municipality

[40] 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.

[41] Sunday times website avaible at https://www.timeslive.co.za/news/south-africa/2020-01-10-drought-ravaged-northern-cape-to-be-declared-a-disaster-area/

evapotranspiration being almost 20 times greater than rainfall experienced, further highlighting the drought tendencies in the area[40].



Approximate location of Gamsberg Smelter Project

Figure 7: Average annual temperature[40].

Prevailing winds in the region are mainly experienced during the night in a southerly direction with Westerly winds being experienced in the daytime. Wind speeds are generally low, with monthly average wind speeds ranging from 3.3 m/s to 4.3 m/s[42]. During the dry period, dust concentration levels increase due to drier conditions and are dispersed by the prevailing winds[40].

4.1.2 *Water*

The Namakwa District Municipality falls within the Orange and Berg-Olifants Water Management Areas. The Orange River is the main river system in the Namakwa District Municipality[43]. At the source of the Orange River within the Lesotho Mountains, rainfall is approximately 2 000mm per annum and decreases as the river flows in a western direction towards the Atlantic Ocean. Evaporation rates conversely increase from east to west[44]. The Namakwa District receives variable rain that is very low compared to the rest of South Africa, particularly for the northern areas of the Namakwa District which receives less than 100mm of rainfall annually. As such the area is

[42] ERM, 2013. Climate Change Specialsit Study, Vedanta Gamsberg ESIA.

[43] Namakwa District Muncipaility, 2017. Climate Change Vulnerability Assessment and Response Plan. Pretoria, South Africa

[44] SA Places, Orange River. Available at https://www.places.co.za/html/orangeproject.html

considered a water stressed region and climate change is predicted to exacerbate water availability as a result of increasing temperatures and evaporation rates.

The Gamsberg Zinc Mine is located at a watershed between two quaternary catchments, with a small water catchment area on the top of the Gamsberg inselberg which can experience seasonal to perennial flows[45]. The main drainage line running parallel to the N14 is the most significant watercourse in the area. This drainage line drains water to the Orange River, the main water body in the Namakwa District situated approximately 33km to the north of the site. The total water demand for the proposed Gamsberg Smelter Project, Black Mountain Deeps Mine, Pella, Pofadder and Aggeneys towns has been estimated as 44 ML per day which will be used for mining, industrial, drinking, sanitation and other miscellaneous uses[46]. Authorisation is in place for this water to be sourced from the Orange River where the extraction point is located near Pella.

From Figure 8 it is evident that at the source of the Orange River within Lesotho, water depletion and drought risk is of concern, particularly as this area supplies large quantities of the water to the river. This has resulted in a baseline overall stress categorised as extreme, particularly west of the proposed Gamsberg Smelter Project site. Water resources within the Orange River Basin are considered to fully utilised and future water demands are likely to be met through transfers from other river basins[47]. Future water flow risks within the Orange River include dam development and diversions of water flow within the headwaters of the Lesotho Highlands scheme.

[45] Vedanta, 2019. Enivornmental and social impact assessment and associated permitting for the proposed Gamsberg Smelter project.

[46] Vedanta, 2019. Pre-Feasibility Study Report, 250kTPA Zinc Smelter with infrastructure at Gamsberg, South Africa.

[47] N, Diederichs, *et al.*, 2005. Orange River Basin Baseline Assessment Report, available at https://www.researchgate.net/publication/275341782_Orange_River_Basin_-_Baseline_Vulnerability_Assessment_Report

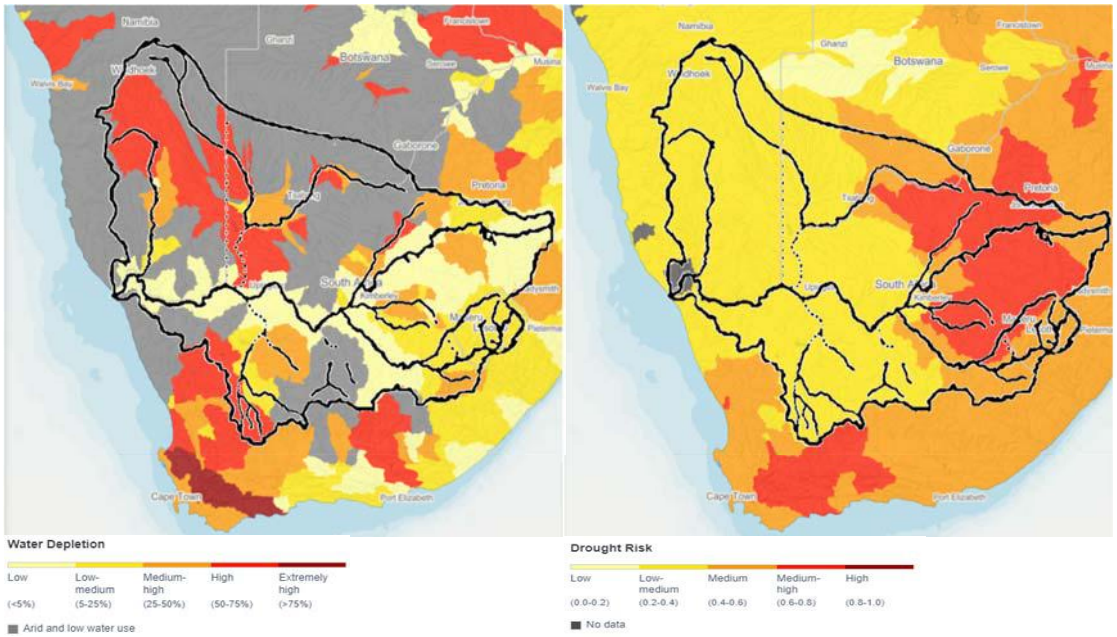


Figure 8: Baseline water depletion and drought risk with the approximate location of the Orange River Basin boundaries[47,48]

[48] Hofste, R., S. Kuzma, S. Walker, E.H. Sutanudjaja, et al. 2019. "Aqueduct 3.0: Updated Decision Relevant Global Water Risk Indicators." Technical Note. Washington, DC: World Resources Institute. Available online at: https://www.wri.org/publication/aqueduct-30

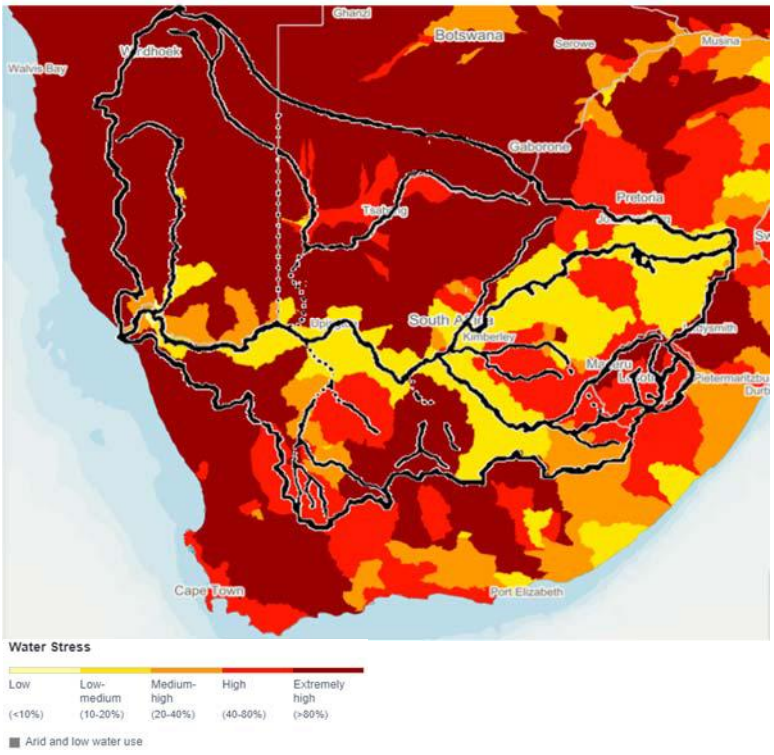
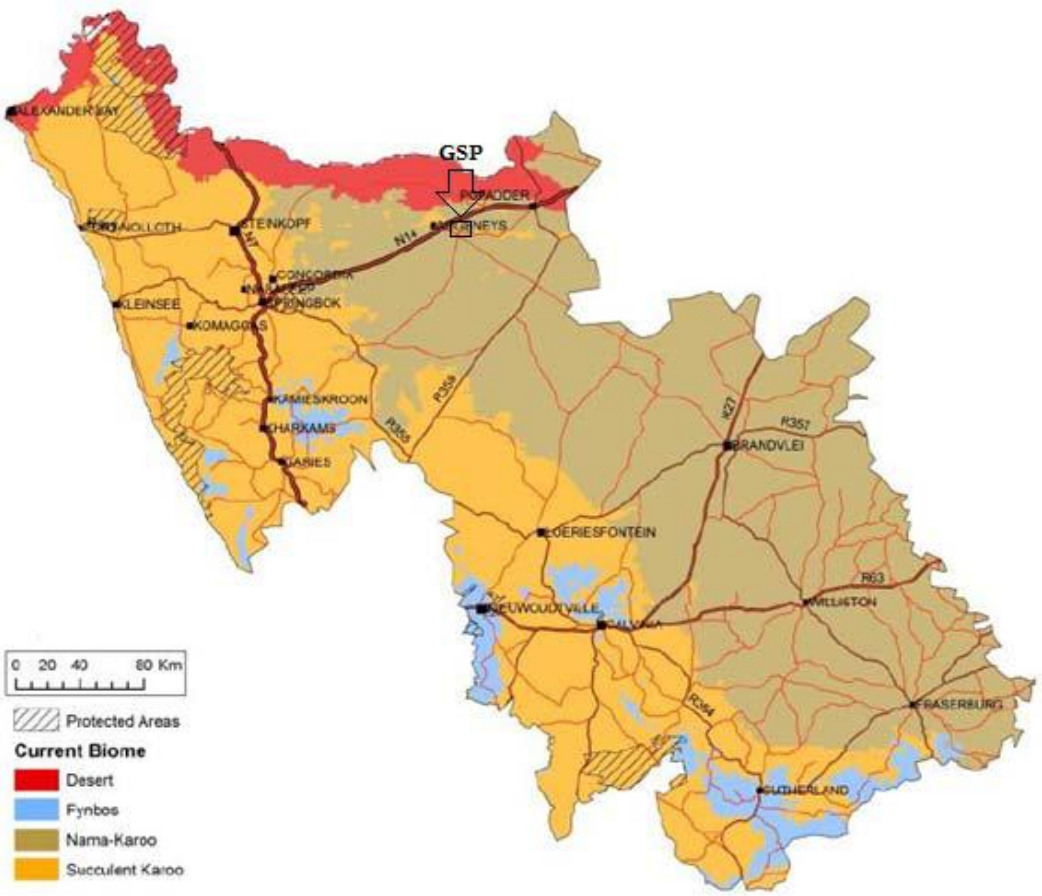


Figure 9: Baseline overall water risk for the approximate location of the Orange River Basin boundaries[47,48]

Groundwater resources are more abundant than surface water features with groundwater predominantly found within secondary fractured-rock aquifers located in the surrounding areas. Due to the limited availability of surface water, groundwater is a key resource particularly for livestock farmers and those heavily dependent on this water resource.

4.1.3 *Biodiversity*

The proposed Gamsberg Smelter Project is proposed to be developed within the biodiversity hotspot of the Succulent Karoo Biome illustrated as a narrow strip in Figure 10 surrounded by the Nama-Karoo biome.



☐ Approximate location of Gamsberg Smelter Project

Figure 10: Current Distribution of biomes in the Namakwa District Municipality[49]

Within the Gamsberg ecosystem, there are 397 plant species of which 16 are recognised as endemic[50]. The Succulent-Karoo area is one of 35 biodiversity hotspots in the world. The region contains the largest number of succulent plant species per area with over 400 unique species.

Due to the rich biodiversity within the Gamsberg area, a Biodiversity Offset Agreement (BOA) has been signed between Black Mountain Mining (Pty) Ltd and the Northern Cape Department of Environment and Nature Conservation (DENC). Furthermore, Black Mountain Mining (Pty) Ltd has compiled a Biodiversity Management Plan (BMP) which gives effect to the commitments in respect of the Biodiversity Offset Agreement[51] as well as the conditions for environmental authorisation, specialist reports and the environmental management programme.

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[49] 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.

[50] SRK 2016. Gamsberg Mine Environmental Management Programme Amendment, Black Mountain Mining (Pty) Ltd.

[51] Vendanta, 2019. Enivornmental and social impact assessment and associated permitting for the Gamsberg Smelter Project.

4.1.4 *Socio-economic context*

The socio-economic context refers to communities and/or settlements (urban and rural) that would be impacted, both directly and indirectly, by climate change. The social-economic context is important because it contributes from a labour and service provision perspective. In addition, the social context could also impact operations from a social volatility and vulnerability perspective. Social tensions, safety and poverty/inequality could impact operations at the proposed facility.

The town of Aggeneys is the closest town to the proposed Gamsberg Smelter Project, situated 25km west of Gamsberg Zinc Mine. Aggeneys has an estimated population of 2 500 people of which 750 are permanently employed by Black Mountain Mining (Pty) Ltd [51]. The next closest towns are Pella, 33 km North of Gamsberg Zinc Mine, of which agriculture is the primary economic activity for its 4 000 residents and Pofadder 45km east of Gamsberg Zinc Mine with an estimated population of 6 500 people. Black Mountain Mining (Pty) Ltd sources labour form both the Nama Khoi and Khâi-Ma Local Municipalities[53] and it has been identified by the Namakwa District Municipality that mineral beneficiation is a potential economic opportunity for the area. Therefore, vulnerable communities will increasingly look to such developments for economic upliftment which may increase social pressure on the proposed Gamsberg Smelter Project and potentially impact on the Gamsberg Smelter Project's social license to operate.

Table 4: Khâi-Ma and Nama Khoi key socio-economic indicators[52].

General Information	Khâi-Ma Municipality	Nama Khoi Municipality
Population	12 333	46 512
Age Structure		
Population under 15	22.2%	21.4%
Population 15 to 64	71.6%	68.1%
Population over 65	6.2%	10.5%
Dependency Ratio (per 100 people)		
People in the age group 0-14 & 65+, supported by age group 15-64	39.6	46.8
Employment		
Unemployment rate[53]	24.5%	23.5%
Poverty		
Poverty rate	24.9%	29.1%
Education 20+		
No schooling aged	2.8%	1.4%

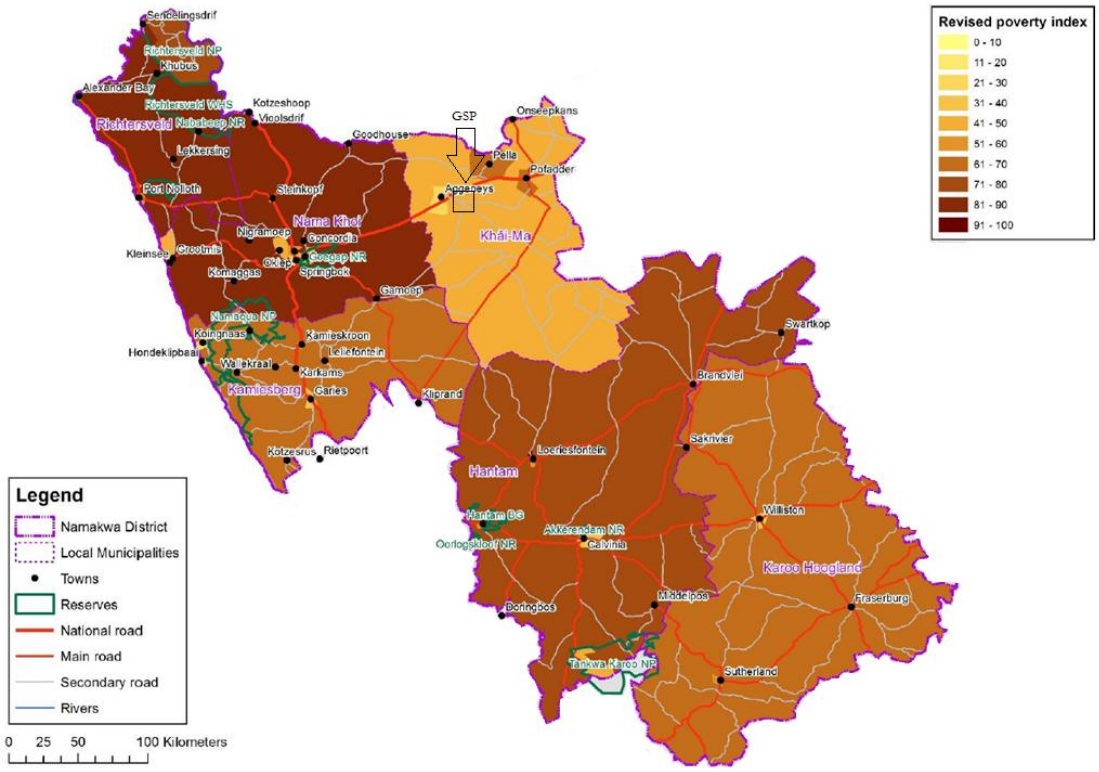
[52] Municipalities of South Africa Website available at https://municipalities.co.za/demographic/1170/Khâi-Ma -local-municipality

[53] Namakwa District Municipality, 2019. Integrated Development Plan Revision 2018/2019. Available at https://www.namakwa-dm.gov.za/wp-content/uploads/2018/04/NDM-Draft-Revised-IDP-2018-2019-28-Mrt-2018.pdf

General Information	Khâi-Ma Municipality	Nama Khoi Municipality
Higher education aged	5.2%	7.6%
Matric	22.2%	23.6%
Households		
Number of households	4 079	14 546
Formal dwellings	92.4%	93.5%
Household services		
Flush toilet connection to sewerage	60.3%	74.2%
Weekly refuse removal	84.9%	89.2%
Piped water inside the dwelling	65.3%	79.8%
Electricity for lighting	87.6%	95.8%

The Namakwa District Municipality is largely a rural municipality with a number of rural and peri-urban settlements having low levels of economic activity and a high dependence on government employment and social grants[54]. The Khâi-Ma and Nama Khoi Local Municipalities indicate higher numbers of individuals living in formal dwellings. Compared to the surrounding local municipalities the Khâi-Ma Local Municipality indicates a lower poverty index level (Figure 11).

[54] 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.



Approximate location of Gamsberg Smelter Project

Figure 11: General poverty index for the Namakwa District Municipality (Map consists of equal weighted summary of values derived from the proportion of low income households, the dependency ratio, the lack of access to services and the lack of access to goods)[49]

Mining is the main source of income in the Northern Cape and contributes, overall, approximately 27% to South Africa's Gross Domestic Product (GDP)[42]. The Khâi-Ma Local Municipality contributes approximately 10.3% to the regional GDP of which mining operations in Aggeneys contributed the most significant proportion[42]. Mining has become an important contributor to poverty alleviation within the area. However, the Khâi-Ma Local Municipality has seen a significant increase in the unemployment rate from 17.4% in 2004 to 24.5% in 2014 and as a result, increased reliance on state support[53].

5 IMPACT OF THE PROPOSED GAMSBERG SMELTER PROJECT ON CLIMATE CHANGE

The GHG emission impacts of the proposed Gamsberg Smelter Project are analysed in terms of both South Africa's national GHG inventory and climate change, as well as the global inventory and climate change. The impact on South Africa's inventory is the departure point for this assessment because the inventory is one of the tools which government uses to determine national and sectoral GHG mitigation targets, which are set within the context of the global emissions inventory and climate change.

5.1 The Role of Zinc in the Emerging Low Carbon Economy

Metals will continue to play a role in the transition to a lower carbon economy, both globally and nationally. Wind, solar, and energy storage batteries will form a critical component of this transition as a means to provide sustainable energy alternatives and related storage options. The International Renewable Energy Agency notes that the share of renewable energy in primary energy supply would grow from less than one-sixth today to nearly two-thirds in 2050 in the Renewable Energy Roadmap Case they prepared[55].

Zinc is a key mineral in the development of solar technologies and also a necessary metal for both geared and direct drive wind turbines. In addition, sulphuric acid, as a product from the proposed Gamsberg Smelter complex is used in copper smelters. Copper mines using the solvent extraction electro-winning process need sulphuric acid to turn ore into copper metal. Copper is an essential component of renewable energy technologies including wind and solar, since it is an effective electrical conductor with great thermal properties.

Renewable energy technologies and project roll-out will continue to grow as global pressure continues to rise with regards to climate change and limiting GHG emissions. The World Bank indicates that the low carbon technology requirements, and hence relevant metals demand, rises rapidly between the 4°C and 2°C scenarios[56]. In this regard metals such as zinc play an important role in enabling the growth of the renewable energy sector.

5.2 Quantification of the Project's GHG Emissions

The proposed Gamsberg Smelter Project's construction and operational GHG emissions are summarised below (Table 5). The emissions are grouped into direct (scope 1), indirect (scope 2) and other indirect (scope 3) sources for both phases of the project's lifetime.

Table 5: Summary of the GHG emissions calculated for the proposed Gamsberg Smelter Project

Emission categories	Total (construction and operations)	Construction (for whole construction period)	Operations (over the life of project)
Direct (Scope 1) Emissions	62 340 tCO_{2e}	12 598 tCO_{2e}	49 742 tCO_{2e}
Indirect (Scope 2) Emissions	21 636 859 tCO_{2e}	4 859 tCO_{2e}	21 632 000 tCO_{2e}
Other Indirect (Scope 3) Emissions	2 890 653 tCO_{2e}	88 486 tCO_{2e}	2 802 167 tCO_{2e}
Total Emissions	24 589 852 tCO_{2e}	105 942 tCO_{2e}	24 483 909 tCO_{2e}

The proposed Gamsberg Smelter Project is expected to generate approximately 62 340 tonnes of carbon dioxide equivalent (tCO_2e) of **direct emissions** over the proposed smelter's lifetime, which is approximately 0.3% of the total calculated emissions. The direct emissions are from the

55 IRENA (2019), Global energy transformation: A roadmap to 2050 (2019 edition), International Renewable Energy Agency, Abu Dhabi.

56 The World Bank (2017), The growing role of minerals and metals for a low carbon future, The World Bank, Washington.

combustion of diesel and are considered to be within the direct control of the proposed Gamsberg Smelter Project (this pertains to stand-by generators and not routine consumption). The bulk (99.7%) of the proposed Gamsberg Smelter's lifetime emissions are, however, categorised as indirect emissions which arise during the operations phase (Figure 12).

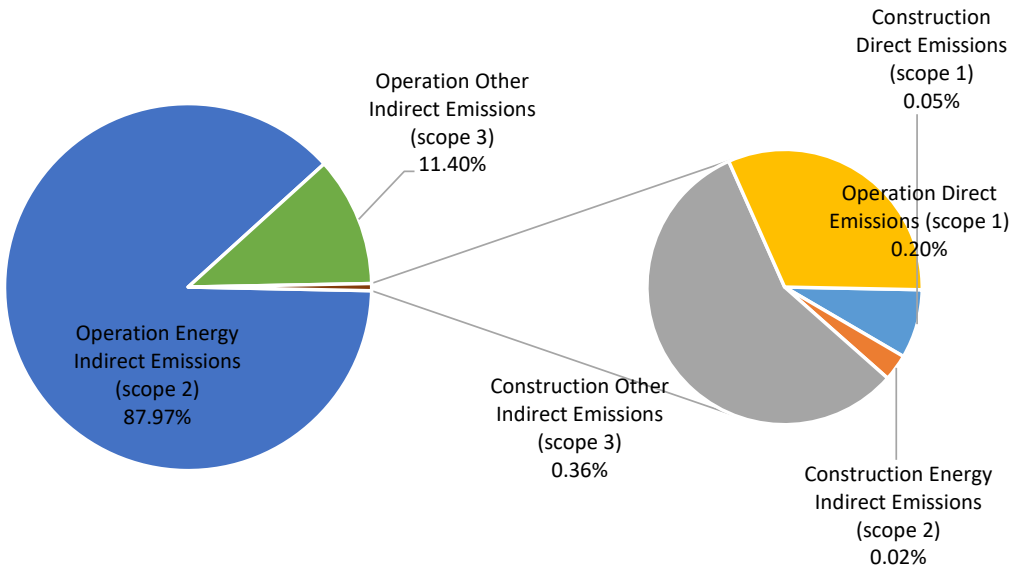


Figure 12: Distribution of lifetime GHG emissions generated by the proposed Gamsberg Smelter Project

Emissions from the consumption of grid-based electricity (energy indirect emissions) during operations accounts for the majority (87.9%) of the project's lifetime emissions. The bulk of the other indirect emissions (scope 3) arise from fuel and energy related activities as a result of the large electricity consumption.

Some activity and technological alternative scenarios have been considered as part of the proposed Gamsberg Smelter Project's environmental authorisation application to the Department of Mineral Resources. Therefore, an alternative GHG inventory scenario has been calculated. The layout alternatives of the proposed Gamsberg Smelter Project do not impact on the project's GHG inventory. The scenarios relate to the percentage of electricity consumption sourced from renewable energy. The results of these scenarios can be seen in the table below.

Table 6 Renewable energy scenarios - Emissions

	30% Renewable	50% Renewable	90% Renewable	100% Renewable
Total electricity consumption	20 800 GWh	20 800 GWh	20 800 GWh	20 800 GWh
Electricity consumed from renewables	6 240 GWh	10 400 GWh	18 720 GWh	20 800 GWh
Electricity consumed from Eskom	14 560 GWh	10 400 GWh	2 080 GWh	-
Scope 1 emissions (Construction)	12 598 tCO_2e	12 598 tCO_2e	12 598 tCO_2e	12 598 tCO_2e
Scope 1 emissions (Operation)	49 742 tCO_2e	49 742 tCO_2e	49 742 tCO_2e	49 742 tCO_2e
Scope 2 emissions (Construction)	4 859 tCO_2e	4 859 tCO_2e	4 859 tCO_2e	4 859 tCO_2e
Scope 2 emissions (Operation)	15 142 400 tCO_2e	10 816 000 tCO_2e	2 163 200 tCO_2e	-
Scope 3 emissions (Construction)	88 486 tCO_2e	88 486 tCO_2e	88 486 tCO_2e	88 486 tCO_2e
Scope 3 emissions (Operation)	2 105 056 tCO_2e	1 640 316 tCO_2e	710 834 tCO_2e	478 464 tCO_2e
Total emissions	**17 403 141 tCO_2e**	**12 612 000 tCO_2e**	**3 029 719 tCO_2e**	**634 148 tCO_2e**

5.3 Impacts on GHG Inventories

To gain a comprehensive understanding of the impacts of the proposed Gamsberg Smelter Project's emissions, one must consider the emissions within the context of the national and international GHG reduction plans.

5.3.1 *South African Context*

The IPCC's Fifth Assessment Report[57] indicates that in order to limit the effects of climate change to a 2°C average temperature increase, the world can emit 1 010 gigatons of CO_2e from 2012 onwards. This figure is termed the global carbon budget. South Africa's share of this budget can be calculated based on the national population as a percentage of the global population. According to Stats SA in 2018, the national population was 58 million people while the global population is 7.7 billion people[58]. South Africa's carbon budget is therefore roughly 7 572 Mt CO_2e.

The following impact ratings have been identified by Promethium Carbon as a means of benchmarking GHG inventories, over the lifetime of the specific activity, regarding emissions occurring within the boundary of South Africa (explained in Sections 2.1.2:

- **Low (inventory of 10 thousand tCO_2e):** 0.00013% of South Africa's carbon budget;

[57] DEA, 2017a. South Africa's Third National Communication under the United Nations Framework Convention on Climate Change, Pretoria: Department of Environmental Affairs.

[58] Worldometers, 2019. Current world population. Available at http://www.worldometers.info/world-population/

- **Medium (inventory of 1 million tCO_2e):** 0.013% of South Africa's carbon budget; and
- **High (inventory of 10 million tCO_2e):** 0.13% of South Africa's carbon budget.

These impact ratings have been developed over the course of a number of projects. The re-evaluation of the magnitude criteria (as represented by NEMA) was done to align the magnitude to climate change.

The proposed Gamsberg Smelter Project's calculated emissions inventory in terms of South Africa's remaining portion of the global carbon budget is presented in the following table.

Table 7 The Gamsberg Smelter Project's emissions relative to South Africa's carbon budget

Category	Emissions	Percentage
South Africa's carbon budget	7 572 $MtCO_2e$	
Scope 1 and 2 emissions (project life)	21.7 $MtCO_2e$	0.29% of SA's carbon budget
Scope 1, 2 and 3 emissions (project life)	24.6 $MtCO_2e$	0.32% of SA's carbon budget

The impact of the proposed Gamsberg Smelter's GHG inventory is considered to be **high** due to the total inventory being approximately 0.2% of South Africa's carbon budget.

The emission intensity of zinc produced in proposed Gamsberg Smelter Project is shown in the table below:

Table 8: Emission intensities from project

Emission source	Intensity	International benchmark
Scope 1 emissions	0.015 tCO_2e/tonne zinc	0.002 - 0.030 tCO_2e/tonne zinc[59]
Scope 2 emissions	6.7 tCO_2e/tonne zinc	1.8 – 4.6 tCO_2e/tonne zinc[60]
Scope 3 emissions	0.86 tCO_2e/tonne zinc	Not quoted

Table 8 shows that the direct emission from the proposed Gamsberg Smelter Project will be in the range of internationally accepted values. The same is not true for the energy indirect emissions (Scope 2), but this should be seen in the context that the South African electricity grid has a very high emission factor. Should the proposed Gamsberg Smelter Project be able to access lower emission electricity, the energy indirect (Scope 2) emissions can come down significantly. The

[59] Methodology for the free allocation of emission allowances in the EU ETS post 2012, Sector report for the non-ferrous metals industry, By order of the European Commission, Study Contract: 07.0307/2008/515770/ETU/C2

[60] Bosch P, Kuenen J, GHG efficiency of industrial activities in EU and Non-EU, TNO report, TN0-034-UT-2009-01420 RPT-ML

impact of sourcing electricity from renewable sources on the scope 2 and 3 intensities are shown in the table below.

Table 9 Renewable energy scenarios - Emission intensities

	30% Renewable	50% Renewable	90% Renewable	100% Renewable
Scope 2 intensity	4.66 tCO_2e/tonne zinc	3.33 tCO_2e/tonne zinc	0.7 tCO_2e/tonne zinc	0 tCO_2e/tonne zinc
Scope 3 intensity	0.65 tCO_2e/tonne zinc	0.5 tCO_2e/tonne zinc	0.2 tCO_2e/tonne zinc	0.15 tCO_2e/tonne zinc

5.4 Impacts on Climate Change

The high-level impacts from the perspective of the national and international GHG inventories do not necessarily reflect the impacts of the proposed Gamsberg Smelter project from the domestic or global environmental perspective.

Each participant in the global economy has a responsibility to minimise their contributions to climate change. Therefore, there is a collective responsibility to address climate change despite the inability to attribute specific GHG emissions from the proposed Gamsberg Smelter Project to specific effects on climate change.

The impacts of the proposed Gamsberg Smelter Project's GHG emissions have been assessed in Table 11, as per the Environmental Impact Criteria detailed in Section 2.1 of this report. The assessment results indicate that the activities undertaken in the proposed Gamsberg Smelter Project will produce GHG emissions that will contribute to the national and global inventories and climate change.

Table 10: Climate change impacts of the Gamsberg Smelter Project's emissions during construction

Nature: The GHG emissions produced as a result of the construction will contribute to the global phenomenon of anthropogenic climate change. Numerous global changes are likely to manifest due to climate change, although none that can be attributed directly or indirectly to the specific GHG emissions of any individual source, such as the proposed Gamsberg Smelter. The total Scope 1 and 2 emissions from the construction phase of the project are calculated to be 17 456 tCO_2e, which is 0.002% of the South African carbon budget of 7 572 $MtCO_2e$. The total emissions from the smelter's construction are therefore between the 0.00013% 'low' rating threshold and the 0.013% 'medium' rating in relation to the national carbon budget, as set out in section 5.3.1.

Below illustrates the indicators with and without mitigation.

	Without Mitigation	With Mitigation
Spatial Scale	National/International	National/International
Duration	Permanent	Permanent
Magnitude	Medium	Medium
Probability	Definite	Definite

Significance	Low to Medium	Low to Medium
Status of impact	Negative	Negative
Reversibility	None	None
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Slight reduction possible	Yes
Mitigation: The majority of emissions in the construction period arise from the combustion of diesel. These emissions can be reduced slightly through the use of fuel additives which improve fuel economy.		
Cumulative impacts: The emissions from the construction phase of the project are cumulative. The increase of GHGs in the atmosphere lead to an increase in global temperatures and resultant climatic changes.		
Residual risks: GHGs have the ability to remain in the atmosphere over significant periods of time. This contributes to the rapid increase in global temperatures. The effects of these emissions are not immediately felt but are residual in that the impacts of climate change, as a result of the proposed Gamsberg Smelter's emissions during construction, will remain even after the smelter has been decommissioned.		

Table 11: Climate change impacts of the Gamsberg Smelter Project's emissions during operations

Nature: The GHG emissions produced as a result of the proposed Gamsberg Smelter's operations will contribute to the global phenomenon of anthropogenic climate change. Numerous global changes are likely to manifest due to climate change, although none that can be attributed directly or indirectly to the specific GHG emissions of any individual source, such as the proposed Gamsberg Smelter. The total Scope 1, 2 and 3 emissions from the operational phase of the smelter are calculated to be 24.4 $MtCO_2e$, which is 0.2% of the South African carbon budget of 7 572 $MtCO_2e$. The total emissions from the smelter's operation are therefore above the 0.13% 'high' rating threshold in relation to the national carbon budget, as set out in section 5.3.1. Below illustrates the indicators with and without mitigation.		
	Without Mitigation	**With Mitigation**
Spatial Scale	National/International	National/International
Duration	Permanent	Permanent
Magnitude	High	High
Probability	Definite	Definite
Significance	High	High
Status of impact	Negative	Negative
Reversibility	None	None
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	Yes, to an extent

Mitigation: The majority of the proposed Gamsberg Smelter's operational emissions arise from the use of purchased electricity. These emissions, and related "high impact" rating, can be significantly reduced through the use of zero emission energy technologies like solar power and considering energy efficient technologies. Currently there are some renewable energy options being considered, as per the project feasibility study and information made available post the feasibility report by the Client, however the impact rating would remain "High". Even though the impact rating for the project remains high, the use of renewable energy will significantly mitigate the potential impacts of the project on climate change. It is recognised that the project feasibility study did not consider solar power to be a viable option due to the fact that it is not available at night. However, current trends such as increasing energy costs; an unstable energy grid and the continuous decrease in technology costs related to battery storage must be taken into consideration. In this regard solar technology, coupled with battery storage, could be or become a viable energy option over the short-term. The proposed Gamsberg Smelter Project should, as part of its continuous GHG assessment and monitoring processes, include an analysis of the trends related to solar technology changes.
Cumulative impacts: The emissions from the operational phase of the smelter are cumulative. The increase of GHGs in the atmosphere leads to an increase in global temperatures and resultant climatic changes.
Residual risks: GHGs have the ability to remain in the atmosphere over significant periods of time. This contributes to the rapid increase in global temperatures. The effects of these emissions are not immediately felt but are residual in that the impacts of climate change, as a result of the smelter emissions, will remain even after the various activities within the smelter have been decommissioned.

The results of the assessment indicate that the emissions from the proposed Gamsberg Smelter Project's operations will have a **high impact** rating.

There are options to mitigate the GHG emissions of the smelter during the operational phase of the various activities. These options will not alter the impact of GHG emissions on climate change in terms of the extent, duration or probability of the impacts. Mitigation can only alter the magnitude of the impact primarily by reducing the quantity of GHG emissions.

The results of different renewable energy options on the impact rating is shown in the table below. The results indicate that the magnitude of the emissions can be mitigated by sourcing electricity from renewable energy sources. The impact rating will be medium if 100% of the smelter's electricity requirements can be met using renewable energy.

Table 12 Renewable energy scenarios - Impact rating

	30% Renewable	50% Renewable	90% Renewable	100% Renewable
Total electricity consumption	20 800 GWh	20 800 GWh	20 800 GWh	20 800 GWh
Electricity consumed from renewables	6 240 GWh	10 400 GWh	18 720 GWh	20 800 GWh
Electricity consumed from Eskom	14 560 GWh	10 400 GWh	2 080 GWh	-
Scope 1 emissions (Construction)	12 598 tCO_2e	12 598 tCO_2e	12 598 tCO_2e	12 598 tCO_2e
Scope 1 emissions (Operation)	49 742 tCO_2e	49 742 tCO_2e	49 742 tCO_2e	49 742 tCO_2e
Scope 2 emissions (Construction)	4 859 tCO_2e	4 859 tCO_2e	4 859 tCO_2e	4 859 tCO_2e
Scope 2 emissions (Operation)	15 142 400 tCO_2e	10 816 000 tCO_2e	2 163 200 tCO_2e	-
Scope 3 emissions (Construction)	88 486 tCO_2e	88 486 tCO_2e	88 486 tCO_2e	88 486 tCO_2e
Scope 3 emissions (Operation)	2 105 056 tCO_2e	1 640 316 tCO_2e	710 834 tCO_2e	478 464 tCO_2e
Total emissions	**17 403 141 tCO_2e**	**12 612 000 tCO_2e**	**3 029 719 tCO_2e**	**634 148 tCO_2e**
% of remaining carbon budget	0.23%	0.17%	0.04%	0.008%
Impact rating	**High**	**High**	**High**	**Medium**

6 IMPACTS OF CLIMATE CHANGE ON THE PROPOSED GAMSBERG SMELTER PROJECT

Due to the interdisciplinary and cross cutting nature of climate change, climate vulnerability is not limited to direct operations only but includes the social, economic, environmental and institutional contexts that interact with the changing climate. As a result, climate change impacts and risks cut across a number of sectors including the economy, the water sector and social ecosystems, illustrated below.

Figure 13: Climate risks impacting various sectors (adopted)[61]

The Northern Cape is already experiencing detrimental climate change impacts such as drought which is currently crippling development within the province. The Namakwa District Municipality has acknowledged that climate change poses a significant threat to the development of the region, the environment and its residents. To adequately account 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 proposed Gamsberg Smelter Project faces a number of climate change related risks across its core operations, value chain, and broader network. The risks are classified as either low or high depending on the emissions scenario. The following sections outline a climate change impact assessment identifying the impacts climate change may have on the proposed Gamsberg Smelter Project.

6.1 Emission scenarios and impact analysis

Emissions scenarios for this report are described by using RCPs which are scenarios that include time series of emissions and concentrations of GHGs, aerosols and chemically active gases together with land use/land cover. Each RCP scenario represents only one of many possible scenarios that would lead to specific radiative forcing, and therefore global warming characteristics. Each RCP also emphasizes the trajectory taken over time to reach the outcome[62].

[61] Engelbrecht, F. & Davis, C. a. T. T., 2016. Climate Change over South Africa: From trends and projected changes to vulnerability assessments and the status quo of national adaptation responses, Pretoria: CSIR.

[62] Moss et al., 2010, The next generation of scenarios for climate change research and assessment, Nature 463, 747 – 756.

Four RCP's are used in the Fifth IPCC Assessment[63] as a basis for climate predictions and projections. The scenarios include a stringent mitigation scenario (RCP2.6), two intermediate scenarios (RCP4.5 and RCP6.0) and one scenario with high GHG emissions (RCP8.5). Scenarios without additional efforts to constrain emissions ('baseline scenarios') lead to pathways ranging between RCP6.0 and RCP8.5. RCP2.6 is representative of a scenario that aims to keep global warming likely below 2°C above pre-industrial temperatures. The RCP scenarios are consistent with the wide range of scenarios in the literature as assessed by IPCC working Group III on mitigation of climate change where roughly 300 baseline scenarios and 900 mitigation scenarios are categorized by CO_{2e}-concentration by 2100[64].

The two emissions scenarios considered in this assessment are:

1. No GHG mitigation scenario RCP 8.5: business as usual or baseline scenario where global average temperatures are expected to increase by 6 °C from pre-industrial levels, which could, for example, increase the risk of heat stress; and
2. Mitigation scenario RCP 4.5: intermediate measures are put in place with a view to limiting global average temperatures to 2 °C.

Focus was placed on these two scenarios due to the fact that the business as usual scenario gives a good indication of how climate change would precipitate as a function of the current conditions. RCP 4.5 was selected as an intermediate scenario with a conservative representation of limited efforts to reduce global average temperatures. This is more consistent with most national policies that aim to effect limited change within one area of national life over a timeframe such as South Africa.

It is important to note that different components related to the proposed Gamsberg Smelter Project (core operations, value chain and broader network) will experience risk differently and with varying impact. For the purposes of this assessment, risks have been classified as either physical or transitional (regulatory), as indicated in the recommendations of the Task-force on Climate-related Financial Disclosures.

The relationship between physical and transitional risks under the unmitigated and mitigated emissions scenarios are typically inverse of one another, as illustrated in Figure 14.

[63] IPCC, 2014. Fifth Assessment Report of the IPCC, s.l.: s.n.
[64] IPCC, 2014. Fifth Assessment Report of the IPCC, s.l.: s.n.

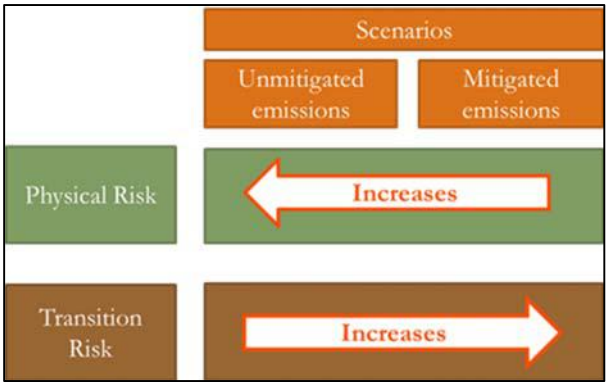


Figure 14: Forward looking scenario analyses[65]

Typically, physical risks are higher under an emissions scenario with low mitigation where few to no policies and measures are put in place to reduce emissions, resulting in increased physical impacts. Correspondingly, transitional risks would typically be low under an unmitigated emissions scenario, as transitional risks are generally associated with policy implementation aimed at adaptation. Conversely, physical risks are typically lower and transitional risks are higher under a mitigated emissions scenario.

The climate change projections for the Gamsberg and the Khâi-Ma Local Municipality are provided in Table 13.

[65] Promethium Carbon

Table 13: Future Climate change within the Gamsberg area[66,67]

Climate change impact	Current	RCP 4.5	RCP 8.5
		The projected change for the period 2021 to 2050, relative to the baseline period (1961 to 1990).	
Temperature	Annual average temperature of 21,6°C for the Gamsberg area.	Average increase of between 2°C and 2.9°C. Average temperatures would increase up to approximately 22.9°C.	Average increase of between 2.6°C and 3.3°C Average temperatures would increase up to approximately 23.3°C.
Very Hot Days (>35°C)	Up to 45 very hot days for the Gamsberg area.	Increase of up to 64 very hot days. This indicates an increase of up to 42%.	Increase of up to 65 very hot days. This indicates an increase of up to 44%.
Rainfall	Mean annual rainfall of 110mm[68]	Annual average rainfall could change between minus 50mm and plus 28mm.	Annual average rainfall could change between minus 72mm and plus 30mm.
		RCP 8.5[69] (Additional resources used)	
Floods Risk	Low flood risk for the Gamsberg area.	Low flood risk for the Gamsberg area.	
Droughts Risk	The Northern Cape region is currently going through a drought period.	There is an increase in drought tendencies projected in the Gamsberg area with extreme drought predicted in Aggeneys high drought risk predicted in Pofadder and medium drought risk predicted in Pella.	
Fire Risk	Isolated fire incidence is considered rare for the majority of the area.	The towns of Aggeneys, Pella and Pofadder all show a slight increase in fire risk.	

The impacts of climate change are discussed further in relation to the proposed Gamsberg Smelter Project core operations, value chain, social environment and the natural environment by considering changes in temperature and water.

66 CSIR. 2019. Green Book: Adapting South African settlements to climate change. Available at: www.greenbook.co.za

67 SAEON. 2019. SA Risk and Vulnerability Atlas Online Spatial Database 2.0. Available at: http://sarva2.dirisa.org/atlas

68 ERM, 2013. Climate change specialist Study, Vendanta Gamseberg ESIA.

69 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.

6.2 Core operations and the value chain

6.2.1 *Temperature impacts*

The Gamsberg area is expected to see a very high increase in average temperature (between 2˚C and 3.3˚C by 2050) that will pose a significant concern for staff, particularly for individuals working outside who are exposed to extreme heat. Heat stress is a major occupational health risk and can directly impact labour productivity and thereby operations at the proposed Gamsberg Smelter Project. High heat exposure restricts an employee's physical functions, their capabilities and ultimately work productivity and capacity. Globally, a temperature increase of 1.5˚C by the year 2100 could lead to a 2.2% drop in working hours which could result in a cost to the global economy of $2.4 trillion[70]. Such increases in temperature will be of even greater concern in the long term where the temperature is expected to increase even further (above 4˚C) and therefore, may make conditions outside increasingly difficult to work in.

From a maintenance and even a living conditions perspective, an increase in temperature and frequency of hot spells will require an increase in cooling demand. High temperatures could require the extended use of air conditioners and ventilation systems. This may also increase diesel consumption in the vehicles and electricity consumption in buildings, thereby presenting an additional cost burden. Increased temperatures in conjunction with dry spells will also necessitate an increase in water use within the facilities in an effort to regulate temperature and ensure that operating temperatures are not exceeded. Therefore, increased temperatures may result in an increase in water demand. In an area where water is scarce, this will increase pressure on current water reserves.

6.2.2 *Water impacts*

The water stress specifically related to climate change was assessed using the World Resource Institute's (WRI) Aqueduct tool[71]. The tool defines water stress as the ratio of total withdrawals to total renewable supply in the area and uses thirteen different risk categories including physical, regulatory and reputational risks to determine water risk. Projected changes in water availability or impacts on water resources show how climate change is expected to affect water stress in the area and thereby highlights the water risks to operations. Water risk is considered from a regional perspective with a specific focus on climate change risks faced by the Orange River as it is the main water source in the area.

The WRI Aqueduct tool indicates that the overall baseline water risk for the area where the Gamsberg Zinc Mine is located as "*extremely high*". However, in order to understand the water

[70] International Labour Organization, 2019. Increase in heat stress predicted to bring productivity loss equivalent to 80 million jobs, , viewed 26 July 2019, https://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_711917/lang--en/index.htm

[71] Hofste, R., S. Kuzma, S. Walker, E.H. Sutanudjaja, et. al. 2019. "Aqueduct 3.0: Updated Decision Relevant Global Water Risk Indicators." Technical Note. Washington, DC: World Resources Institute. Available online at: https://www.wri.org/publication/aqueduct-30

risks the proposed Gamsberg Smelter Project may face, one needs to consider the water risks which face the Orange River Basin as these impact water quality and quantity within the Orange River.

For the purposes of this assessment, water stress considers changes in water parameters under RCP 8.5 up to the year 2040 in relation to the baseline conditions. Projections indicate water supply to decrease for the majority of the basin area while demand is projected to increase particularly in the northern and eastern areas of the basin[71]. This results in much of the eastern regions of the catchment basin indicating an increase in overall water stress by between 1.4 and 2 times the baseline status[71] These projections are likely to result in dry periods that will impact water flow in the Orange River and can impact water supply both in terms of quantity and quality for the proposed Gamsberg Smelter Project. As the proposed Gamsberg Smelter Project is a large water consumer (estimated at 28,26 ML per day[72]), these risks will need to be appropriately considered as this will have a significant impact on operations at the proposed Gamsberg Smelter Project as well as water availability within the area.

Furthermore, increased temperature and varied rainfall will also impact freshwater levels as well as the quality of the water. Heatwaves and dry spells can exacerbate water quality by reducing the oxygen concentration of the water as a result of the rapid increase in decompositions of organic matter. Water degradation may be further intensified by eutrophication[73] and algal bloom as a result of higher temperatures which can create an environment for these organisms to rapidly proliferate. This is further exacerbated by agricultural and industrial pollution which increases the chemical and nutrient load entering the river. This is particularly relevant for areas where there are numerous agricultural establishments impacting water bodies. The culmination of these impacts may have significant ramifications for the proposed Gamsberg Smelter Project in that it may require an increase in efforts to treat water for the project.

The Department of Environmental Affairs (now Department of Environment, Forestry and Fisheries) has noted that the occurrence and magnitude of large floods of the Orange River has been significantly reduced, (particularly during the summer) and a large reduction in the occurrence and magnitude of smaller floods with return periods of 1:1 year to 1:10 years[74]. This change in flow is largely a function of water flow manipulation due to human interventions upstream. The abstraction and regulation of water (due to the presence of 20 major dams and numerous weirs within its catchment) has altered river inflows from a pronounced seasonal flow to a nearly even flow distribution throughout the year. In particular, the Gariep and Vanderkloof dams have altered river flow due to regulation for hydropower generation[75]. Such impacts have resulted in an

[72] Vedanta, 2019. Pre-Feasibility Study Report, 250kTPA Zinc Smelter with infrastructure at Gamsberg, South Africa.

[73] When a body of water becomes overly enriched with minerals/nutrients which induces excessive microorganism growth.

[74] Department of Environmental Affairs, 2015. Draft Orange River Mouth Ramsar Site Strategic Estuarine Management Plan, available at https://www.environment.gov.za/sites/default/files/docs/orm_sitestrategic_estuarinemanagementplan.pdf

[75] Birdlife South Africa, 2015. *Orange River Mouth Wetlands*, available at https://www.birdlife.org.za/iba-directory/orange-river-mouth-wetlands/

estimated reduction in natural flow of 56%[76]. Maintaining river flow is not only important for sustaining ecological systems but also for maintaining water quality as stagnant water can deteriorate and therefore require treatment before use. Therefore, it is important that the ecological integrity of the river is appropriately maintained through determination, implementation and monitoring of Environmental Flow Requirements[77].

In terms of extreme rainfall events, it is projected that the intensity and variability of rainfall are going to increase as a result of increasing temperature and evaporation. These impacts are expected to increase the frequency of extreme rainfall events. Such events can result in flooding (particularly where flooding cannot be controlled upstream) of the Orange River which can impact pumping infrastructure necessary for water delivery to the proposed Gamsberg Smelter Project. In addition, flash flooding pose major risk to the Smelter and the mine in terms of infrastructure damage and health and safety.

With regard to electricity, Eskom would initially be the sole electricity supplier to the proposed Gamsberg Smelter Project. In this regard, climate change impacts on electricity supply will consider impacts that Eskom may face. It is anticipated that Eskom will be adversely affected particularly with regards to their need for increased cooling due to increased temperatures related to climate change. This is particularly relevant as the bulk of the Eskom power stations are situated in the Mpumalanga region which is a water stressed province with future projections indicating that the province is going to become increasingly drier and hotter. Increased temperatures together with water scarcity (as a result of increased drought predictions) and constraints in terms of access to water could increase pressure on the Eskom grid. This could not only impact supply but may also require increased cooling the costs of which may be passed on to the electricity consumers.

Furthermore, regulatory risks related to carbon tax will also increase operational costs. It is expected that Eskom could pass through the costs associated with carbon tax onto the electricity consumers during the second phase of the carbon tax (2023). Petrol and diesel are already taxed at the pump and uncertainty pertaining to the roll-out of the tax post 2023 could further indicate risks associated with increased prices for fuels. In addition the Carbon Tax could impact the prices of other consumables such as water and food which also require electricity for delivery and production.

6.3 Social environment

Climate change impacts will be considered on socio-economic aspects as well as the broader social network. How badly a person or group of people will be affected will depend not only on their exposure to climate change impacts but also on their social vulnerability to change in climate – that is, how well they are able to cope with and respond to events like flash floods, drought and

[76] DWAF (Department of Water Affairs and Forestry). 2003. Preliminary ecological reserve determinations for estuaries. Determination of the Preliminary Ecological Reserve on a Rapid Level for Orange River Estuary. Final Draft. Prepared submitted to DWAF by the CSIR. CSIR Report ENV-S-C 2003-113. Stellenbosch, South Africa.

[77] N, Diederichs, et al., 2005. *Orange River Basin Baseline Assessment Report*, available at https://www.researchgate.net/publication/275341782_Orange_River_Basin_-_Baseline_Vulnerability_Assessment_Report

heatwaves. The main poverty drivers for the Khâi-Ma and Nama Khoi Local Municipalities are unemployment and lack of education[78]. Further indicators of social-economic vulnerability for these two municipalities are illustrated in
Table 4 under section 4.1.4 and highlight vulnerabilities to the disruptive impacts of climate change.

Two key climate change trends of specific relevance to the socio-economic context of these local municipalities have been identified, namely: declining rainfall patterns for the area and an increase in daily minimum average temperatures. These two trends will have challenging impacts for the area due to high numbers of vulnerable groups.

6.3.1 *Temperature impacts*

The health impacts of extreme heat range from direct heat stress and heat stroke, to exacerbations of pre-existing heart failure, and even an increased incidence of acute kidney injury from dehydration in vulnerable populations. Furthermore, long-term heat exposure can exacerbate chronic diseases, including cardiovascular and respiratory disease, through indirect microbial and vector-borne pathways. Elderly people, children younger than 12 months and people of poor health are particularly sensitive to these changes and are the most vulnerable groups to climate change[79]. Increased temperatures and extreme events such as heat waves are also likely to increase illnesses and injuries, especially for individuals who have compromised immune systems as a result of diseases such as HIV. Negative impacts on the well-being of employees in terms of these climate related impacts could result in a less productive workforce and as a result, impact operations. Furthermore, continued impacts of heat on the population could lead to a decline in health, especially in vulnerable areas, which will place strain on existing, limited health services in the area.

6.3.2 *Water impacts*

Water is an essential community resource and essential for community wellbeing, yet, for the Gamsberg Zinc Mine area, water is a particularly sensitive resource as the area is categorised as water stressed. With projections of increased rainfall variability, increasing drought occurrences and an increase in clean water scarcity, climate change threatens the wellbeing of surrounding communities.

Drought has been noted as one of the most severe socio-economic factors that the Northern Cape Province has ever faced and as a result, the National Disaster Management Centre of the national Department of Cooperative Governance and Traditional Affairs (COGTA) has recently made an allocation of R 42 million to the Northern Cape for the purchasing and distribution of relief feed through the Department of Agriculture, Land Reform and Rural Development (DALRRD)[80].

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[78] Namakwa District Municipality, 2019. Integrated Development Plan Revision 2018/2019. Available at https://www.namakwa-dm.gov.za/wp-content/uploads/2018/04/NDM-Draft-Revised-IDP-2018-2019-28-Mrt-2018.pdf

[79] Watts, N., Amann, M., Ayeb-Karlsoon, S. & Belesova, K. e. a., 2018. The Lancet Countdown on health and climate change: from 25 years of inaction to a global transformation for public health. *The Lancet,* 10 February, 391(10120), pp. p.581-630.

Projections of increased drought means less water will be available to dilute wastewater discharges and irrigation return-flows to rivers. Additionally, enhanced evaporation rates due to climate change is known to cause a deterioration in water quality as a result of increased salt concentrations in dams, wetlands and soil/plant systems. This results in reduced water quality and associated downstream health risks to aquatic ecosystems. These issues result in less water being available for irrigation and drinking purposes, which impacts negatively on the livelihoods of communities, especially in rural areas. Furthermore, projections of reduced annual rainfall could constrain water service delivery and limit access to potable water, specifically within informal communities.

Within the Northern Cape, entire communities have recently reported being without water for days, due to a lack of supply[80] which often results in an additional cost burden as individuals need to go and buy drinking water. Of particular concern are subsistence farmers with limited options to adapt and alleviate drought conditions affecting crop and livestock production which can have devastating impacts on their livelihoods. Under these drought conditions, increased water use by the proposed Gamsberg Smelter Project could result in community volatility and reputational damage. Social volatility, as a result, may affect operations and the workforce together with the company's social license to operate.

6.4 Natural Environment

6.4.1 *Temperature and water impacts on biodiversity*

The Succulent Karoo Biome, within which the proposed Gamsberg Smelter Project is located, is known globally as a biodiversity hotspot. This is due to the unique environmental conditions of the region which has resulted in the proliferation of endemic plant species. Climate change will impact biodiversity, plant species distribution and species composition, mainly, as a result of the following impacts:

- Increasing temperatures;
- Increasing evaporation (particularly in the northeast of Namaqualand);
- Increasing carbon dioxide concentration;
- Varied rainfall (particularly during the winter rainfall season); and
- Varied amounts of mist, dew and fog.

The Gamsberg inselberg is considered as the most important inselberg within the Bushmanland Inselberg Region in terms of biodiversity. As a result, as part of the requirements of the Environmental Authorisation issued for the Gamsberg Zinc Mine, an Offset Agreement is currently in place as well as a Biodiversity Management Plan (BMP) with a supporting Conservation Area Management Plan (CAMP) to manage the impacts of the Gamsberg Zinc Mine. The impacts of climate change on biodiversity will need to be considered in the efforts made to conserve biodiversity within the offset areas. Climate change impacts on biodiversity within this area are described in more detail below.

[80] Black Mountain Mine, 2019. *Socio-Economic Baseline Report*, Vendanta

A moderate temperature regime together with a highly reliable summer rainfall period is a current characteristic of the Succulent Karoo area compared to other winter rainfall deserts of the world[81]. Additionally, moisture from the Benguela upwelling system produces frequent advective fogs, which can extend up to 100km inland and provide a very important additional source of water for plants, particularly in the summer[82,83]. The regular provision of water has enabled plants to replenish water loss on a sequential basis which has resulted in high levels of endemism for the area as plants have grown accustomed to these cycles[82]. Testament to this is the spring-flowering annuals (daisies, geophytes, dwarf succulents, and stone plants) which are heavily dependent on the region's predictable winter rainfall regime[82]. Additionally, dwarf leaf succulents show high correlations with winter rainfall reliability and seasonality rather than annual totals[84,85].

Figure 15 and Figure 16 illustrate the projected shift in biome conditions. Desert biome conditions are projected to shift southwards from Namibia in the next 50 years with a continuation of this trend in the future[86]. Therefore, the Succulent Karoo Biome and Nama Karoo Biome surrounding the Gamsberg area are expected to experience increased pressure in terms of biome shift towards Desert biome conditions. A result of this is an increased risk to biodiversity loss as these conditions do not favour growth conditions for succulent plant species currently endemic to the area. Additionally, within the Gamsberg area, there is less resilience to climate change impacts, therefore illustrating an increased vulnerability.

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81 R.M Cowling, KJ Esler and P. W. Rundel, 1999. *Namaqualand, South Africa, an overview of a unique winter-rainfall desert ecosystem*, Plant Ecology 142: 3-21.

82 D, Guo et al. 2017. *Climate Change impacts on Dwarf Succulents in Namibia as a Result of Changes in Fog and Relative Humidity*, Journal of Water Resource and Hydraulic Engineering, Vol 6 57-63.

83 To accurately understand the water cycle within the Namaqualand's area assessments of changes in dewfalls and coastal fog are required in order to have an improved vision of future changes in water availability for the region.

84 Werger, M. J. A. & Morris, J. W. 1991. *Climatic control of vegetation structure and leaf characteristics along an aridity gradient*. Ann. Bot. 49: 303–215

85 Cowling, R. M. & Hilton-Taylor, C. 1994. *Patterns of plant diversity and endemism in southern Africa: an overview*. Strelitzia 1: 31– 52

86 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.

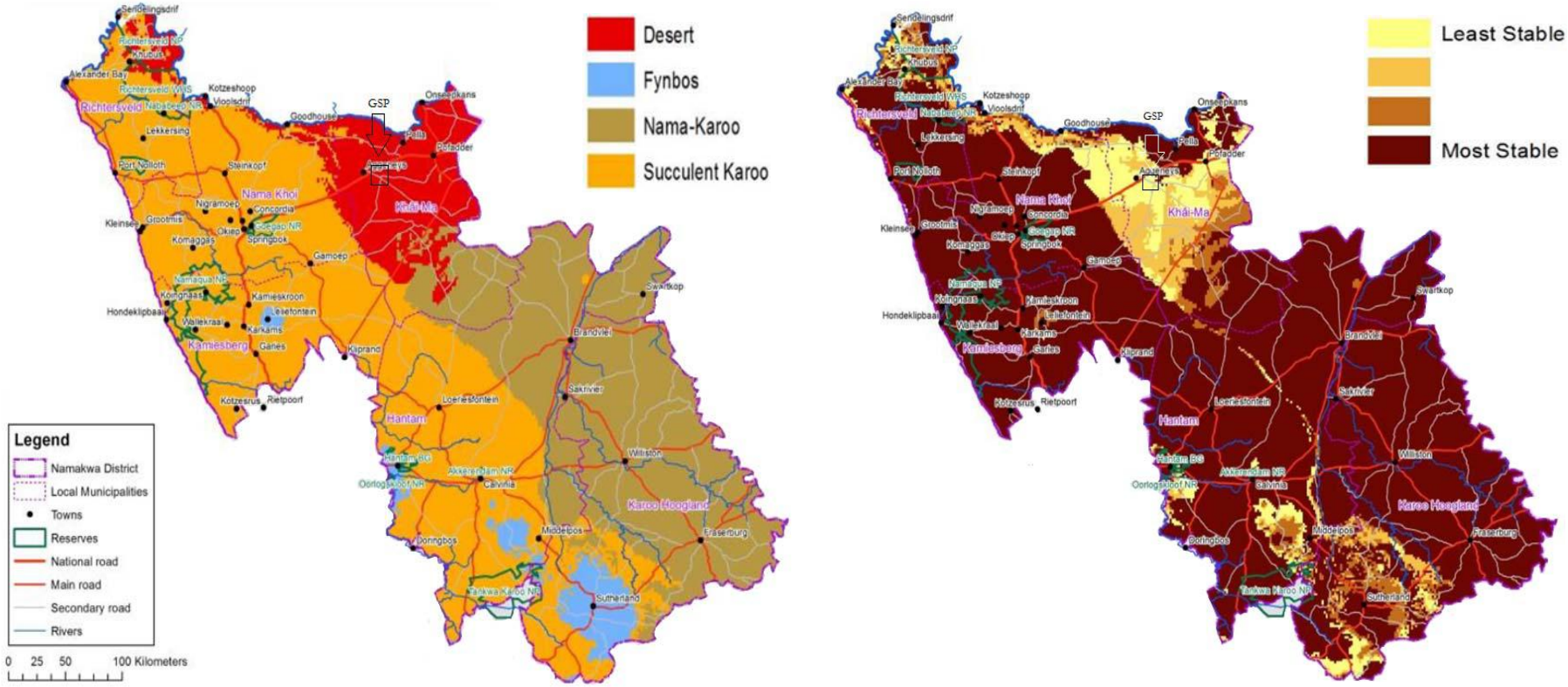
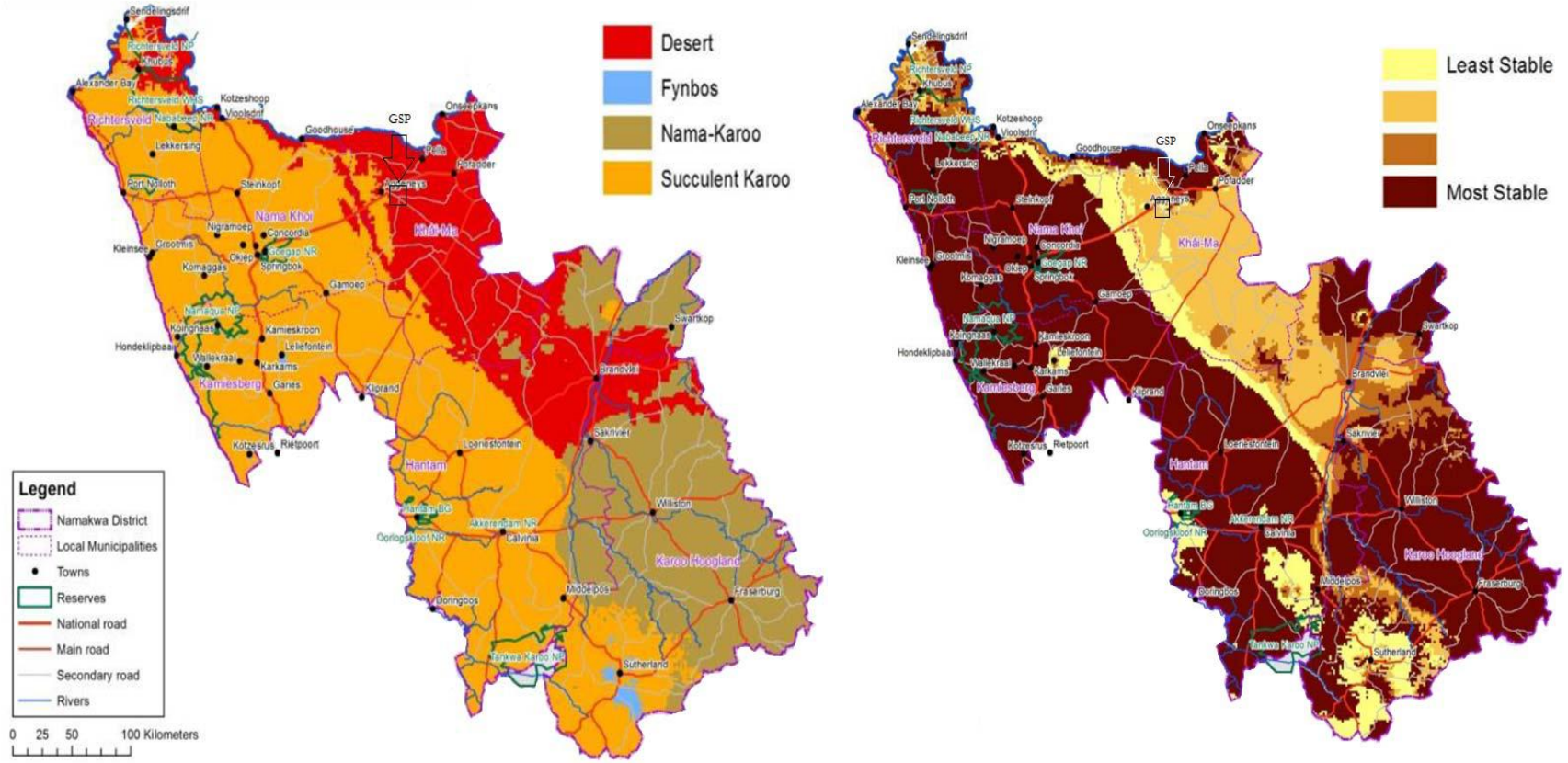


Figure 15: Map illustrating impacts to biomes within the next 50 years (left) together with the areas of stability in response to climate change (right) [54].



Approximate location of Gamsberg Smelter Project

Figure 16: Map illustrating impacts to biomes within the next 100 years(left) together with the areas of stability in response to climate change (right) [54].

Prolonged hot spells, particularly during the end of the growing season have been shown to have negative physiological effects on plants in the Namaqualand area[87]. Furthermore, Broennimann et al.[88] have found that geophytes and succulent species are particularly vulnerable to changes in winter rainfall, indicating a possible decline in species richness of 41% for the Succulent Karoo Biome in future. Additionally, most Namaqualand succulents have extremely shallow rooting systems in order to gain moisture from fog, dew, and limited winter rainfall. This evolutionary adaption has come as a result of the unique regular provision of water in the area. With an increase in rainfall variability, the probability of a decrease in winter rainfall is likely which will result in an increase in drought-induced mortalities particularly with regards to species with shallow roots systems that have little buffering capacity[81]. While the broad climatic conditions of the Succulent Karoo Biome may remain in the short term, local extinction may occur due to the changes in local climate conditions which will have drastic consequences for species reliant on very specific and regular conditions. Such impacts will need to be considered with regards to conservation efforts in order to best create an environment where these plants will be able to survive.

6.5 Adaptive capacity

The adaptive capacity is assessed through both ecological and socio-economic aspects in order to determine the overall vulnerability to climate change.

6.5.1 *Ecological adaptive capacity*

Ecological adaptive capacity refers to the natural features which provide climate resilience. These features include:

- Riparian corridors and buffers;
- Coastal corridors;
- Altitude, temperature and rainfall gradients;
- Areas of high plant endemism;
- Refuge sites including south-facing slopes and kloofs; and
- Priority large unfragmented landscapes.

These environmental features provide essential ecosystem services that improve climate change resilience and thereby improving climate change adaptation. Examples of these services included[49]:

- Erosion control;
- Water production and purification;
- Buffering communities from extreme weather events (flood attenuation);
- Increasing natural resources; and
- Providing habitats for plants and animals.

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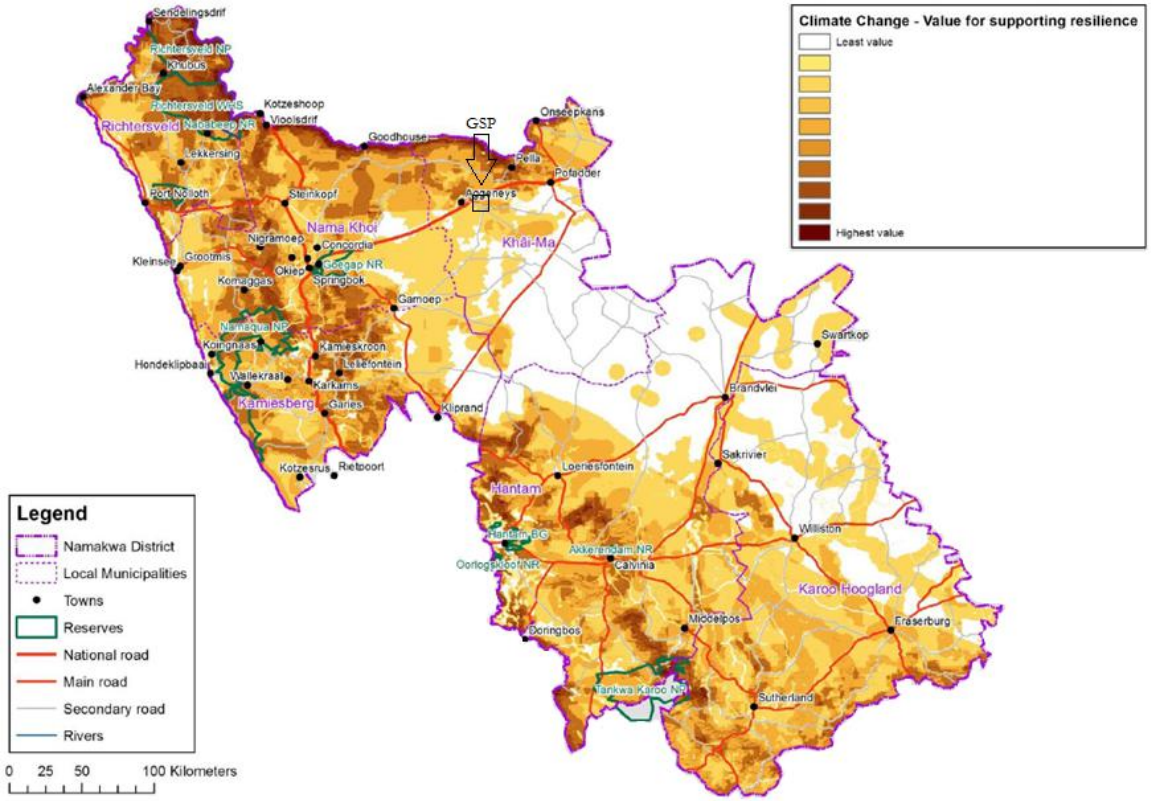
87 Steyn H, Van Rooyen N, Van Rooyen M, Theron G. *The phenology of Namaqualand ephemeral species.* The effect of water stress. J Arid Environ. 1996;33(1):49–62. http://dx.doi.org/10.1006/jare.1996.0045

88 Broennimann O, Thuiller W, Hughes G, Midgley GF, Alkemade JR, Guisan A. *Do geographic distribution, niche property and life form explain plants' vulnerability to global change*? Global Change Biol. 2006;12(6):1079–1093. http://dx.doi.org/10.1111/j.1365-2486.2006.01157.x

Natural areas supporting resilience are mapped out in Figure 17, derived from the Climate Change Vulnerability Assessment for the Namakwa District[54] conducted.From this figure, it is evident that the Gamsberg area overlays areas of medium to high value in terms of climate-resilient ecosystems and thereby illustrates lower vulnerability to climate change. Retaining these areas in a natural state as far as possible will help support healthy ecosystem services.



Approximate location of Gamsberg Smelter Project

Figure 17: Natural areas supporting climate-resilient ecosystems[54]

6.5.2 *Socio-economic adaptive capacity*

The labour characteristic for the Khâi-Ma and Nama Khoi Local Municipalities are illustrated in (Table 14). From this table, it is evident that the proportion of people unemployed and economically inactive is significant. Unemployment is a driver of poverty, which in turn, is the most influential aspect which undermines a community's adaptive capacity to climate change impacts. This is due to an inability to financially respond to climatic events (such as drought) that can disrupt the provision of essential products and services.

Table 14: Labour Characteristics for the Khâi-Ma and Nama Khoi Local Municipalities[53]

	Khâi-Ma Local Municipality		Nama Khoi Local Municipality	
	2014		2014	
Employed	4483	75.5%	13025	76.5%

Unemployed	1455	24.5%	4011	23.5%
Economically active	5938	69.7%	17036	54.2%
Economically inactive	2579	30.3%	14406	45.8%
Working age population (15 -64)	8517	100%	31441	100%

As illustrated in Figure 11 the poverty in the town of Aggeneys is considerably lower than the neighbouring towns Pella, Pofadder and Onseepkans which illustrates high poverty indices. This can be largely attributed to the employment that the Black Mountain Mining (Pty) Ltd and Gamsberg Zinc Mine offers. However, poverty rates have been recorded at 24.9% for Khâi-Ma Local Municipality and 29.1% for the Nama Khoi Local Municipality[52]. This highlights the proportion of individuals who cannot afford sufficient quantities of food to sustain a healthy life, illustrating a low adaptive capacity to the disruptive impacts of climate change such as drought which will further exacerbate access to food and water.

Much like unemployment and poverty are barriers to a healthy lifestyle and a driver of higher vulnerability, the needs indicated by the respective municipal Integrated Development Plans (IDPs) as in Table 15 illustrate adaptive capacity challenges for the Khâi-Ma and Nama Khoi Local Municipalities. This highlights the adaptive capacity shortfalls and ultimately the vulnerability of communities to climate change.

Table 15: Khâi-Ma and Nama Khoi IDP needs and challenges (source Socio-economic Baseline Report of the communities impacted by the Black Mountain Mining operations (Gamsberg operation and Swartberg operation) [80]

Khâi-Ma Local Municipality	
Adaptive capacity needs and challenges	Notes
Basic Service and infrastructure needs	
<u>Water</u> **Access to sufficient and clean water to all households every day, including the towns, Pella and Onseepkans**	Projections of increased temperatures and drought tendencies will decrease the availability of clean water in an already water stressed area. Waste water treatment is done through oxidation ponds where increased evaporation would impact the operational efficiency of the works. Increasing temperature and evaporation rates will increase the deterioration of water quality as a result of increasing salt loads in freshwater systems. These impacts will exacerbate adaptive capacity challenges.
<u>Sanitation</u> • **Toilet facilities - flush toilets, not dry systems, for villages; and** • **Public toilets in business areas of Pofadder and Pella.**	
<u>Wastewater</u> • **Removal of wastewater regularly;** • **Extension of sewerage system at Pofadder; and** • **New sewerage system for Pella and Onseepkans**	

Khâi-Ma Local Municipality	
Adaptive capacity needs and challenges	Notes
Housing • **New structures for inhabitants without decent shelter;** • **Completion/repair of defects of houses not on standard;** • **Replacement of clay structures at Pella; and** • **Serviced residential stands (all communities).**	An increased frequency of storm events and high winds may cause infrastructure damage both to roads and housing. Housing damage may result in uninhabitable housing conditions leading to further exposure to climate change impacts. Road damage could make access more challenging and can result in transport delays and productivity decline. This can come as a financial cost burden for the areas and can decrease adaptive capacity in this regard.
Roads • **Gravel roads to be paved (all towns);** • **Pofadder-Onseepkans road to be tarred;** • **Maintenance of existing streets including tar roads (Pofadder);** • **Re-gravelling of Witbank access road;** • **Grading of gravel roads;** • **Storm water drainage (all towns); and** • **Maintenance of access road to Pella.**	
Social needs	
Health Services • **Full time medical officers based at Pofadder;** • **Part-time nurse at Witbank;** • **Medicines to be made available;** • **Cooling facilities for medicines – Witbank;** • **Extension of clinic at Blyvooruitsig;** • **Food for patients at Health Care Centre, at Pofadder;** • **Clinic services at Viljoensdraai;** • **New clinic building at Sending, Onseepkans;** • **Waiting room for patients at Sending and at Pofadder Health Care Centre for patients to be transported to Springbok, Upington or Kimberley;** • **Transport for patients;** • **Improved Ambulance services; and** • **Adequate vehicles and equipment for quicker response to fires.**	An increase in the number of very hot days and an increase in average temperatures will induce heat stress and can result in respiratory and cardiovascular diseases. Additionally, drought in particular, can significantly affect food systems and thereby compromise food availability which can lead to food insecurity which will have further indirect health impacts. This is particularly relevant for subsistence farmers within the area. Furthermore, increased temperatures increase conditions for the incubation and transmission of waterborne diseases to Riverside communities. Such impacts illustrate how climate change can exacerbate a vulnerable health system which does not have the adaptive capacity to manage such impacts.
Education • **Assistance with school fees;** • **Skills Development;** • **New school building for Pella and Onseepkans Primary Schools;** • **Transport for children to school from Onseepkans to Pofadder; and** • **Financial Assistance (bursaries).**	Addressing the physical impacts of climate change not only relates to infrastructure resilience, but also social resilience and building the necessary skills and capacities in communities to address climate change impacts. Education provides the know-how to adapt to climate change. Therefore, barriers to improving education typically transpire into lower education levels which
Welfare	

Khâi-Ma Local Municipality	
Adaptive capacity needs and challenges	Notes
• **Crèche for Children of Working mothers (Viljoensdraai);** • **Additional classrooms and kitchen facilities at Sending, Onseepkans; and** • **Early childhood development facilities at Pofadder and Viljoensdraai, Onseepkans.**	results in a lower adaptive capacity to manage the disruptive impacts of climate change.
Economic needs	
• **Skills training;** • **Drought Relief for emerging farmers; and** • **Sustainable jobs.**	Insufficient financial capacity for skills development and drought relief decreases the adaptive capacity to respond to the impacts of climate change.
Nama Khoi Local Municipality	
<u>Environment and land</u> • **Enhance environmental management institutional capacity;** • **Address waste disposal environmental issues;** • **Prevent water pollution (need for water quality monitoring);** • **Remove alien invasive plants;** • **Promote environmental awareness;** • **Climate Change Awareness Programs and support for eco school program;** • **Promote waste recycling within the area; and** • **Mitigate the risk of disasters.**	The ecological adaptive capacity refers to the natural features which provide climate resilience. Loss of biodiversity and degradation of natural habitat due to significant land use alterations will impact the ability of the environment to respond to climate change. Ensuring these features are appropriately maintained and conserved will increase the adaptive capacity of the area to withstand impacts associated with climate change. Environmental awareness and appropriate management efforts should support conservation efforts by the respective responsible parties.
<u>Infrastructure</u> • **Upgrade roads and associated storm water drainage;** • **Upgrade water storage and sanitation services;** • **Upgrade water supply;** • **Provide electricity;** • **Upgrade electricity supply;** • **Upgrade sanitation services;** • **Purchase additional equipment (in order to provide and/or maintain essential infrastructure services); and** • **Promote and facilitate the provision of integrated human settlements Renewable energy.**	Extreme events associated with climate change are projected to increase damage to infrastructure within the municipality area. (drought, wind, more intense periods of rain) Furthermore, with a projection of more frequent drought tendencies expected for the area, water storage capacity becomes an important adaptive measure to ensure water availability during these periods. Damaged infrastructure in this regard will decrease the adaptive capacity to respond to drought periods. Additionally, the provision of electricity will also need to be managed in the future to ensure energy security. This is particularly relevant with the current challenges faced by Eskom of which one such challenge is

Khâi-Ma Local Municipality	
Adaptive capacity needs and challenges	Notes
	climate change impacting tariffs (through carbon tax and increased cooling demand).
Economic • **Facilitate job creation and local economic development (LED) (to address high unemployment rate);** • **Promote tourism;** • **Promote small business development;** • **Investigate feasibility of recycling mine dumps, establishing small new mines and the prospecting for other minerals;** • **Support existing government departmental projects; and** • **Support sustainable livelihoods programs such as food gardens and one-household-one-hectare program.**	As with the Khâi-Ma Local Municipality, the Nama Khoi Local Municipality faces significant economic limitations hindering skills development and job creation. This undermines the financial ability of individuals to respond to the impacts of climate change.

From Table 15, it is evident that numerous needs are required to be addressed to adequately improve the adaptive capacity of the respective municipalities to the impacts of climate change. At the foundation, these municipalities should focus on poverty alleviation through job creation which is dependent on skill development and education.

6.6 Summary of climate change vulnerability

The climate change vulnerability ratings for the four key areas were determined considering the vulnerability (exposure, sensitivity and adaptive capacity) to temperature and water impacts associated with climate change as assessed in sections 6.1 to 6.5. Table 16 illustrates the vulnerability ratings from this assessment below.

Table 16: Climate change vulnerability rating

Key Areas	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Temperature				
Core operations	High	High	High	High
Value chain	Medium	Medium	Low	Medium
Social environment	High	Medium	Low	High
Natural environment	High	Medium	Medium	Medium
Water				
Core operations	High	High	Low	High
Value chain	High	High	Low	High
Social environment	High	High	Low	High
Natural environment	High	High	Low	High

Table 17: Exposure, sensitivity and adaptive capacity ratings

Impact Exposure, sensitivity and vulnerability	Definition	Impact Adaptive capacity
High	Aspect of Climate Change likely to result in prominent impact associated with significant consequences to site operations/value change/broader community. Significant susceptibility to the effects of climate change and climate variability due to a prominent magnitude and rate of change in climate.	**Low**
Medium	Aspect of Climate Change likely to result in moderate impact associated with material consequences to site operations/value change/broader community. Moderate susceptibility to the effects of climate change and climate variability due to a material magnitude and rate of change in climate.	**Medium**
Low	Aspect of Climate Change likely to result in a minor impact associated with insignificant consequences to site operations/value change/broader community. Minor susceptibility to the effects of climate change and climate variability due to an insignificant magnitude and rate of change in climate.	**High**

It is evident that the proposed Gamsberg Smelter Project will face high climate change risks particularly with regards to water stress that will need to be adequately managed to mitigate the negative impacts on the core operations, value chain and the broader community, including the natural environment.

7 MANAGEMENT MEASURES

7.1 Design considerations for GHG mitigation

The majority of the proposed Gamsberg Smelter Project emissions occur during the operational phase. Therefore, emission mitigation measures would need to be focused on this phase, specifically on electricity consumption, to be effective in reducing the impacts the proposed Gamsberg Smelter Project will have on climate change.

Climate change mitigation is generally centred on four main strategies:

1. Using renewable energies;
2. Using new, more efficient technologies;
3. Retrofitting older equipment over life of operation to be more energy efficient; and
4. Changing management practices or consumer behaviour to be more emissions conscious.

For the proposed Gamsberg Smelter Project, mitigation would be focused on two main aspects, energy efficient technologies and the use of renewable energies. For the purpose of this impact assessment it is assumed that the plant would be constructed using the most energy efficient technologies available. An example of this would be installing variable speed drives on motors and pumps.

The region between Pofadder and Aggeneys, where the Gamsberg Smelter Project will be built, has a very high Direct Normal solar Irradiation (DNI) of approximately 3 000 kWh/sqm[89]. As a result, solar energy is an attractive option for renewable energy plants. Such an installation could be used to reduce the proposed Gamsberg Smelter Project's reliance on grid-based electricity which is predominantly coal-based. This would result in a lowering of Scope 2 emissions which is the plant's largest emissions category. Solar energy would further yield a high Return on Investment because of the higher solar irradiance in the region.

Current trends such as increasing energy costs; an unstable energy grid and the continuous decrease in technology costs related to battery storage must be taken into consideration. In this regard solar technology, coupled with battery storage, could be, or become a viable energy option over the short-term. The proposed Gamsberg Smelter Project should, as part of its continuous GHG assessment and monitoring processes, include an analysis of the trends related to solar technology changes.

A further option for reducing reliance on the national grid system is to make use of the waste heat generated in the roasting process. This waste heat can be recovered and used to generate electricity for consumption in the plant. It has been noted that this is already included in the design provided for this assessment.

7.2 Operational Emissions Management

South Africa's environmental legal framework provides for the mandatory management of emissions by the owners of entities that have operational control over emissions-intensive activities. The *National Pollution Prevention Plans Regulations* and the *National Greenhouse Gas Emission Reporting Regulations* refer.

The *National Greenhouse Gas Emission Reporting Regulations* require entities that are above the defined thresholds to report direct (Scope 1) emissions only, excluding road and off-road transport, to DEFF. The Gamsberg Smelter Project would need to monitor and report their annual (calendar year) direct emissions.

7.3 Adaptation

Because the natural environment is highly complex and highly unpredictable, adapting to the changing climate and developing strategies to respond to these uncertainties is challenging. In this

[89] Centre for Renewable & Sustainable Energy Studies, 2014. *New solar resource maps for South Africa*. Energyblog. Viewed 12 February 2020 https://www.energy.org.za/news/158-new-solar-resource-maps-for-south-africa

regard, the following points should be considered with regard to the climate change adaptation related to the proposed Gamsberg Smelter Project.

- Climate change risks and impacts are highly diverse and context-specific. Planning for adaptation therefore needs to be driven across operations at the proposed Gamsberg Smelter Project and incorporated into appropriate local and external resources, expertise and knowledge to address potential climate risks. Therefore, climate change should form part of the proposed Gamsberg Smelter Project's risk assessment and risk management processes. Focus should be placed on water resource management as the area is projected to face increasing water risk that will increase risks to operations and therefore water recycling will become important.

- Timescales matter. Climate change occurs in short to long-term timescales, with direct and indirect changes and impacts across the life of the project. As such the proposed Gamsberg Smelter Project's processes, structures and systems must consider the linkage of adaptation work across time scales and integrate continuous learning on adaptation.

- Uncertainty - climate change and resultant risks and impacts are difficult to predict with certainty. A framework must be developed with the appropriate flexibility to evolve with the changing climate risks. The project must move from a reactive approach to climate impacts, to pro-active approaches which include precautionary measures to be prepared for future latent risks. Adaptation planning related to the proposed Gamsberg Smelter Project should consider items such as localised disaster risk management plans and/or early warning systems focused on reducing vulnerability and exposure.

- Decision-making processes are at the heart of effective adaptation. The changing climate and its impacts on the proposed Gamsberg Smelter Project require continuous and informed decision-making. This includes reviewing past trends, current conditions and anticipating future scenarios related to climate change on a continuous basis, also within the context of the surrounding social-economic character. In this regard systems and processes, which ensure anticipatory, flexible, locally contextualised decision-making are required. Collaboration with *inter alia* the directly impacted local community, the local municipality and the Minerals Council of South Africa on climate change adaptation could strengthen decision-making capabilities.

- Underlying causes and drivers of vulnerability and economic growth affect resilience to climate change. This may hinder the success of the implementation of adaptation actions. A holistic response to climate change risk and vulnerability management within the proposed Gamsberg Smelter Project is needed to align operational departments as well as link to other key stakeholders such as the DEFF.

8 CONCLUSION

This climate change impact assessment for the proposed Gamsberg Smelter Project considered two perspectives regarding climate change in relation to the project. The first relates to the impact of the project on climate change. The second relates to the impacts of climate change on the project.

These analyses made use of standards and regulatory documents to quantify the impacts described. The documentation used in the development of this report includes:

- ISO/SANS 14064:2006 Part 1;
- Greenhouse Gas Protocol – Corporate Standard;
- Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emissions by Industry;
- Recommendations by the Task Force on Climate-Related Financial Disclosures (TCFD);
- Internationally recognised "Best Practice" documentation, including the International Funding Corporation (IFC) Performance Standards, the European Bank of Reconstruction and Development (EBRD) principles and the Equator principles; and
- Documents related to the Thabametsi Climate Change Impact Assessment.

The proposed Gamsberg Smelter Project would impact on climate change through the inevitable generation of emissions, through both the direct and indirect emissions generated. It is estimated that the total direct (Scope 1) and energy indirect (Scope 2) emissions associated with the proposed Gamsberg Smelter Project will be approximately 21.7 million tCO_2e over its construction and operational lifetime. The upstream and downstream emissions associated with this project (Scope 3) within South Africa is 2.8 million tCO_2e.

Based on the findings stipulated throughout this report, our opinion on the proposed project has been summarised as follows:

- Based on the methodology used to assess the impact of the proposed Gamsberg Smelter Project on climate change, the Gamsberg Smelter Project has a high impact on climate change. This relates predominantly to the substantial requirement and use of grid electricity. There are two mitigating issues to consider in this regard:

    1. The use of zinc, both in terms of zinc ingots as well as the production of sulphuric acid as a by-product (which can be used in the copper smelting process), contributes to the development of a low carbon economy. Zinc product plays an important role in enabling this transition as it supports the growth and development of renewable energy technologies; and
    2. Although the emissions from the proposed Gamsberg Smelter Project are considered high in terms of the methodology used, direct emission from this project will be in the range of internationally accepted values.

- The majority of the emissions related to this project stem from the use of grid-based electricity in South Africa. South Africa currently has a high grid emission factor due to the electricity supply being predominantly coal-based.

- There are options to mitigate the GHG emissions of the smelter during the operational phase of the various activities. These options will not alter the impact of GHG emissions on

climate change in terms of the extent, duration or probability of the impacts. Mitigation can only alter the magnitude of the impact primarily by reducing the quantity of GHG emissions.

- The results of different renewable energy options indicate that the magnitude of the emissions can be mitigated by sourcing electricity from renewable energy sources. The impact rating will be medium if 100% of the smelter's electricity requirements can be met using renewable energy.

Considering the above, approval of this project should not solely consider the high impact. The decision related to approval should rather appreciate the proposed Gamsberg Smelter Project's contribution to the low carbon economy transition and the fact that the emissions are within the range of internationally accepted emission intensity for zinc benchmarks.

In terms of the impacts of climate change on the proposed Gamsberg Smelter Project, this study notes the following:

- The Gamsberg area is expected to see a very high increase in average temperature of between 2˚C and 3.3˚C by 2050 which will pose a significant concern in terms of heat stress. Additionally, an increase in the number of very hot days (>35˚C) will further necessitate an increased cooling demand which will need to be adequately managed to ensure productivity is maintained;

- Water is of concern. Projections indicate water supply to decrease for the majority of the Orange River Basin area while demand is projected to increase particularly in the northern and eastern areas of the basin. This results in much of the eastern regions of the catchment basin indicating an increase in overall water stress by between 1.4 and 2 times the baseline status. These projections are likely to result in dry periods that will impact water flow in the Orange River and can impact water supply both in terms of quantity and quality for the proposed Gamsberg Smelter Project;

- The Succulent Karoo Biome and Nama Karoo Biome surrounding the Gamsberg area are expected to experience increased pressure in terms of biome shift towards Desert biome conditions. These conditions will increase the risk of biodiversity loss as these conditions do not favour growth conditions for succulent plant species which are currently endemic to the area. Offsetting species of concern will thus become more challenging; and

- The Khâi-Ma and Nama Khoi Local Municipalities have a vulnerable population. Poverty rates within these municipalities are high, highlighting a large proportion of individuals who cannot afford sufficient quantities of food to sustain a healthy lifestyle and thereby illustrating a low adaptive capacity to the disruptive impacts of climate change such as drought.

Due to the potential exacerbation of the various social and environmental impacts of the proposed Gamsberg Smelter Project's activities as a result of climate change, we recommend that climate change and its associated risks and impacts should be considered for the following:

a) The Social and Labour Plan (SLP) – Climate change can significantly impact the social economic conditions under which the surrounding communities live. The SLP should therefore consider the impacts of climate change on its workforce, immediate local communities and its potential to support climate resilience in the local municipality; and

b) Closure and Rehabilitation Plan – An extensive and ambitious rehabilitation plan should be developed which refers to both concurrent biodiversity offsetting and post-operational rehabilitation measures which shall be implemented by the project owners. The closure plan and rehabilitation strategies must therefore consider climate change and climate modelling and the potential impacts thereof. These measures should make consistent reference to the predicted climate change impacts which are anticipated to affect the project areas and the possible adaptation measures proposed.