PROMETHIUM CARBON

Specialist Climate Change Assessment Report

For the proposed

Musina-Makhado Special Economic Zone

Musina-Makhado Special Economic Zone (SOC) Limited

Limpopo Economic Development Agency

LEDA
LIMPOPO ECONOMIC DEVELOPMENT AGENCY
AN AGENCY OF THE LIMPOPO PROVINCIAL GOVERNMENT REPUBLIC OF SOUTH AFRICA
ROOTED IN THE FUTURE

August 2019

Executive Summary

This report sets out a climate change impact assessment for the planned Musina-Makhado Special Economic Zone (SEZ). The analysis is based on the judgement in the Thabametsi court case where the court found that environmental impact assessments should consider both the potential impact of a proposed project on climate change, as well as the potential impact of climate change on the proposed project.

The analysis presented in this report considered the climate change impacts of the project in the context of both South Africa's domestic legal environment as well as the international commitments the country has made. The report builds on a 2°C target and will fall short in its recommendations if a 1.5°C target is set, as is envisaged in the Paris Agreement.

In conclusion, this project presents a unique challenge in that the results of this study differ if you look at it in different ways:

- When considered from a South African National perspective, the impacts of the project are:
  - The emission over the lifetime of the project will consume as much as 10% of the country's carbon budget. The impact on the emission inventory of the country is therefore HIGH.
  - The project cannot be implemented in the current regulatory confines when considering following:
    - The Nationally Determined Contribution (NDC) in terms of South Africa's commitment in terms of the Paris Agreement;
    - The Peak Plateau Decline (PPD) emission trajectory; and
    - The Integrated Resource Plan (IRP), which sets out the planned electricity production capacity of the country.
- When considered on an international level, the project could reduce emissions by as much as 10 million tons CO_2e per year, if the plants are built to the recommended emissions intensity specifications.

In the light of the above, the recommendations in the report are:

- Environmental authorisations for the individual plants in the SEZ should only be granted if the following emission intensities can be achieved:

Plant	2°C target intensities for 2030
Coke Plant	0.21 tCO_2e/tonne product
Ferrochrome plant	3.37 tCO_2e/tonne product
Ferromanganese plant	3.37 tCO_2e/tonne product
Silicon-manganese plant	5.18 tCO_2e/tonne product
Carbon steel plant	0.37 tCO_2e/tonne product
Stainless steel plant	0.78 tCO_2e/tonne product
Lime plant	0.87 tCO_2e/tonne product
Cement plant	0.80 tCO_2e/tonne clinker
Sewage treatment plant	0.0005 tCO_2e/tonne water
Water treatment plant	0.0005 tCO_2e/tonne water

- In addition, the environmental authorisation should require a re-assessment of the emission intensities 10 years after the start of operation of the respective plants
- The construction of a coal fired thermal power plant should not be approved unless the plant is fitted with a carbon capture and storage unit that can sequester all emission from the combustion of coal from the starting date of operation.
- The Specialist studies (groundwater, surface water, etc.) for the environment authorisation for each plant in the overall SEZ should specifically address the impact of climate change on each area. For example, the ground water study should address the impact of climate change on the recharge of groundwater, etc. This is also important for all studies related to the social impacts of the projects.
- Water is of critical concern. The study area is already severely water stressed and climatic modelling for the area indicates increased ambient temperatures, prolonged periods of drought and greater rainfall variability. These factors will exacerbate current water risks, both in South Africa and in neighbouring Zimbabwe.
- The Vhembe District Municipality has a vulnerable population. This population is characterised by high levels of unemployment and low levels of education. In addition, there are significant service delivery backlogs within the area. Climate change could worsen the socio-economic conditions of these communities. In addition, due to the location and scale of the SEZ, and given the vulnerability of communities in Zimbabwe and Mozambique, the study area could see an increase in migratory job-seekers. This will further compound social pressures.

This assessment was undertaken by Promethium Carbon under bid number LEDA/AIA/2018/19-2. The Scope of Work as proposed by the Service Level Agreement has been addressed as follows:

Requirements as per Scope of Work depicted in Service Level Agreement	Relevant Chapters of this report
Review of legislation, policy schemes and frameworks applicable to the proposed development	**Chapter 3** sets out the various relevant climate change related documents and strategies pertaining to climate change in terms of global, national, provincial and local level.

Requirements as per Scope of Work depicted in Service Level Agreement	Relevant Chapters of this report
Baseline description of climate change landscape	**Chapter 3** provides an overview of the national, provincial and local context of climate change.
Climate Resilience Assessment	**Chapter 6** discusses the impacts of climate change on the projects which is assessed in terms of exposure, sensitivity and adaptive capacity to inform the proposed SEZ's vulnerability risk rating.
Climate baseline	Chapter 3 discusses the nature of climate change, which includes reference to the pre-industrial era
Climate change projections	**Chapter 3** discusses observed climate change trends and projections on a national. Provincial and local level.
Impact Assessment: Assessment of direct, indirect, cumulative GHG emission impacts during the: • Construction phase • Operational phase • Decommissioning and rehabilitation phase	**Chapter 5** provides the emission intensities of the proposed SEZ and a discussion on the related impact on climate change. As the designs for the various activities and related plants envisaged for the SEZ in terms of their respective construction and decommissioning planning, have not yet been finalised, the emissions for each of these plants in terms of these phases cannot yet be calculated. Therefore, this assessment has determined emission intensities for the various operational activities envisioned within the SEZ (based on available information), required to achieve national and international climate change objectives.
Emissions management measures	Both **Chapter 5** and **Chapter 8** discusses emission mitigation measures.
Proposed development's direct impacts on climate change	**Chapter 5** details the project's direct impact on climate change.
Extent of GHG emissions to arise from the development	**Chapter 5** details the emission intensities, assumed for the SEZ.
How climate change will impact on the project	**Chapter 6** discusses the impacts of climate change on the project.
How predicted climate change effects on the environment at both national and local scale will be aggravated by the project's impacts	**Chapter 6** discusses the impacts of climate change on the project and the related exacerbation of project impacts as a result of climate change.
How impacts can be avoided, mitigated or remedied	Both **Chapter 5** and **Chapter 8** discusses emission mitigation measures.
Assessment of social and environmental costs of the proposed development's GHG emissions	**Chapter 6** discusses the impacts of climate change on the project and the related exacerbation of project impacts as a result of climate change. These impacts are contextualised within the social and natural environment of the study area. **Chapter 5** also

Requirements as per Scope of Work depicted in Service Level Agreement	Relevant Chapters of this report
	provides a detailed assessment of the impact of the project in relation to South Africa's carbon budget.

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Declaration of Independence

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

Details of Specialist

Promethium Carbon

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 assists 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 greenhouse gas inventories for over 60 entities and is proficient in applying the requirements of ISO/SANS 14064-1 and the Greenhouse Gas Protocol's accounting standards, as well as South Africa's greenhouse gas reporting guidelines. Promethium Carbon has also assisted around 40 clients develop climate change risk assessments, which includes the compilation of climate change specialist reports. Promethium Carbon's assessments include thorough analysis of historical and projected weather data specific to the region in which the client operates. Promethium Carbon's assessment of vulnerability goes beyond core operations to include impacts within the supply chain and broader network of the 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 annual 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 (35 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 foot printing. 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.
- 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 13 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 process;
- Drafting Carbon Disclosure Project Climate Change and Water responses;
- Assessment of climate change and energy related regulations;
- 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 3 years, working within the following areas:

- Carbon footprint / Greenhouse gas 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
- 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 1.5 years. Kenneth's experience in climate change includes:

- Carbon footprint / Greenhouse gas inventory development
- Energy efficiency studies

- Data analysis
- Climate Change Impact Assessments

List of Acronyms and Terms

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

Key Terms and Definitions[1]

Climate Change	Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use.
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 gases 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. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary GHGs in the Earth's atmosphere.
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.
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.
Resilience	The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure while also maintaining the capacity for adaptation, learning and transformation.
Mitigation	Mitigation (of climate change), a human intervention to reduce emissions or enhance the sinks of greenhouse gases. Behaviour change efforts can be planned in ways that mitigate climate change and/or reduce negative consequences of climate change impacts.
Adaptation	In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects.
Adaptive capacity	The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.

[1] 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

1 Introduction

Promethium Carbon has been appointed to undertake a Climate Change Impact Assessment as part of the Environmental Impact Assessment process for the Musina-Makhado Energy and Metallurgy Special Economic Zone (EMSEZ, SEZ). The proposed SEZ is located across the Musina and Makhado local municipalities which fall under the Vhembe District Municipality. The Musina- Makhado SEZ objective to create a new heavy industrial hub that forms part of the Trans-Limpopo Spatial Development Initiative.

In accordance with the relevant regulations, an environmental impact assessment process must be completed before project development can proceed. We understand that, in the case of the Musina Makhado SEZ, the current environmental authorisation pertains to the establishment of the SEZ. All activities to be undertaken within the SEZ will be subject to further, individual environmental impact authorisations.

Climate change poses major risks to South Africa. The country is located in one of the three regions of the African continent that will most likely suffer significant adverse impacts with predicted warmer and drier summers, wetter and milder winters and more frequent extreme weather events[2]. The Limpopo province is already experiencing some of these impacts with future predictions indicating increased temperatures and more frequent extreme weather events such a periods of prolonged drought and heat waves[3]. The Province's water resources, are, and will continue to be significantly impacted by climate change. In addition, there is great social vulnerability within the area as a result of high poverty levels, low levels of education and service delivery backlogs. Climate change impacts could further exacerbate these challenges.

The global nature of climate change impact is such that the greenhouse gas emissions from any individual project or source cannot be connected directly to any specific environmental impacts as a consequence of climate change. The analysis presented in this report is presented in the context that, even though the individual GHG emission contribution of a project cannot be directly linked to specific localised climate change impacts, global climate change is significant and can be quantified as such. In other words, the specific greenhouse gas emissions from the SEZ and its eventual tenants cannot be attributed directly to particular climate change effects. Despite this there is a collective responsibility to address the global challenge of climate change and each actor, such as the proposed SEZ, has an individual responsibility to minimise its own negative contribution to climate change.

2 Alex Kirby, "Three African Regions at High Risk from Climate Change," *ClimateCentral,* 12 June 2019. http://www.climatecentral.org/news/climate-hotspots-imperil-parts-of-africa-17417

3 Limpopo Provincial Government, *Limpopo Provincial Climate Change Response Strategy 2016-2020.* 12 June 2019. http://www.ledet.gov.za/wp-content/uploads/2016/11/Limpopo_Climate_Change-Response_Strategy_-2016_2020_Final.pdf

This report covers the climate change impact assessment for the SEZ. As such an assessment cannot be done without providing context to the potential emissions. As the exact build programme for the SEZ has not been finalised, this report is based on the assumption that the following will form part of the SEZ:

- Coal washery
- Coke plant
- Heat recovery power generation
- Thermal power plant
- Ferrochrome plant
- Ferromanganese plant
- Silicon manganese
- Vanadium-titanium magnetite
- High manganese steel
- High vanadium steel plant
- Stainless steel Plant
- Lime plant
- Cement plant
- Refractories factory
- Sewage treatment plant
- Industrial domestic water plant
- Light industrial processing zone
- Machinery zone
- Commercial residential area
- Living area
- SEZ administration centre
- Bonded area

As the detail designs and related process flows of the envisaged SEZ operations are not yet completed, the emissions associated with these activities cannot be calculated. This assessment considers industry benchmarks and best practice emission intensities required to achieve certain national and international climate change objectives. Ultimately these emissions intensities should form the basis of the environmental approvals for the various operations envisaged in the SEZ. This report also presents emission intensities calculated from data received from the project team and puts it in context with the mentioned intensities.

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

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

1. Developing a benchmark greenhouse gas inventory for the SEZ. Due to the fact that detailed information with regards to the operations of each of the activities envisioned for the SEZ is not available, this assessment compiled a benchmark greenhouse gas inventory based on industry benchmarks and current best practice emission intensities. It compares this with high level data provided by the project team.
2. Reviewing the greenhouse gas emissions mitigation options for the project.
3. Conducting an impact assessment of the project:
    a) Considering its contribution to the South African national emissions inventory, the global greenhouse gas inventory, and the potential impacts of the project on the onset of global anthropogenic climate change;
    b) Comparing the emissions associated with the value chain of the 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 project and the project's broader network.
4. Assessing requirements for greenhouse gas emission management activities for the SEZ's operations.

2 Project Description

The following sections provide a context, overview and setting of the proposed Musina-Makhado Energy and Metallurgy SEZ based on information contained in Scoping Report[4] related to the project.

2.1 Regional Project Context

The Musina-Makhado SEZ is developed in the following regional context:

- The Southern African Development Community (SADC) is a Regional Economic Community comprising 16 member states within Southern Africa and promotes sustainable and equitable economic development. The main objectives of SADC are to achieve economic growth, peace and security for the region. South Africa, as a member state aims to promote sustainable development through eradicating poverty by creating employment and sustainable economic growth.

- The Special Economic Zone (SEZ) Programme has been established by the South African Government as a mechanism to enhance economic development by transforming the local economy into a globally competitive industrial economy. The SEZ programmes are intended to contribute towards strengthening South Africa's terms of trade through the export of value added commodities, the creation of stronger value chains and provision of much needed jobs in previously disadvantaged regions.

- The Limpopo Development Plan[5] as well as the National Development Plan[6] emphasize the need for economic growth which is dependent on provincial resources to help develop competitive industrial areas. It is therefore aimed at the need to utilize the use of locally available resources through various industries for the benefit of the province and the country. The proposed Musina-Makhado SEZ is the single largest proposed SEZ development in the country. It is envisaged that Musina-Makhado SEZ will contribute to the transformation of the governmental agenda in the province in terms of providing regional integration with SADC countries and improving local economic growth.

- The proposed location for the Musina-Makhado SEZ is central to various coal resources located as well as other minerals such as iron, nickel, manganese, silica and lime stone, all located within a 200km radius. These minerals could provide the inputs to the prosed

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4 Delta BEC, 2019. *Musina-Makhado Sepeical Economic Zone Development Scopring Report,* Limpopo Province, Revision 01.

5 Limpopo Provincial Government Republic of South Africa: *Limpopo Development Plan 2015-2019*. Viewed 12 June 2019 http://policyresearch.limpopo.gov.za/bitstream/handle/123456789/1335/LDP%20Draft%20Ver.2.4%20Dec.2014.pdf?sequence=1

6 Republic of South Africa: *National Development Plan 2030*. Viewed 12 June 2019. https://www.gov.za/sites/default/files/Executive%20Summary-NDP%202030%20-%20Our%20future%20-%20make%20it%20work.pdf

projects within the SEZ. The proposed SEZ is located on sections of the N1 motorway and the R525 road with a railway line running along the northwest side. This making it strategically positioned as part of the north south corridor and which could improve trade efficiency by providing a trade route to neighbouring countries. Furthermore, the SEZ could create employment opportunities for the areas which will be presented through various mixed use developments of the industrial park. This could improve economic development for the region and thereby positively contribute to the Southern African Development Countries.

2.2 Project Overview

The Musina-Makhado Energy Metallurgical Special Economic Zone (EMSEZ) comprises two sites as designated by the Department of Trade and Industry in July 2016. This report deals specifically with the southern part of the Musina-Makhado SEZ which is located on eight farms (approximately 8,000 hectares) overlapping the border between the Makhado and Musina local municipalities, within the Vhembe District Municipality. The nearest towns are Makhado (located 31 km south) and Musina (located 36 km north) of the proposed SEZ site. This site is situated approximately 34 km from the northern site (Figure 1). The site is a greenfield site and is earmarked for the development of energy and a metallurgical cluster for the production of high-grade steel. The project objective is designed to attract foreign and domestic direct investment to promote industrial development by creating a new heavy industrial hub.

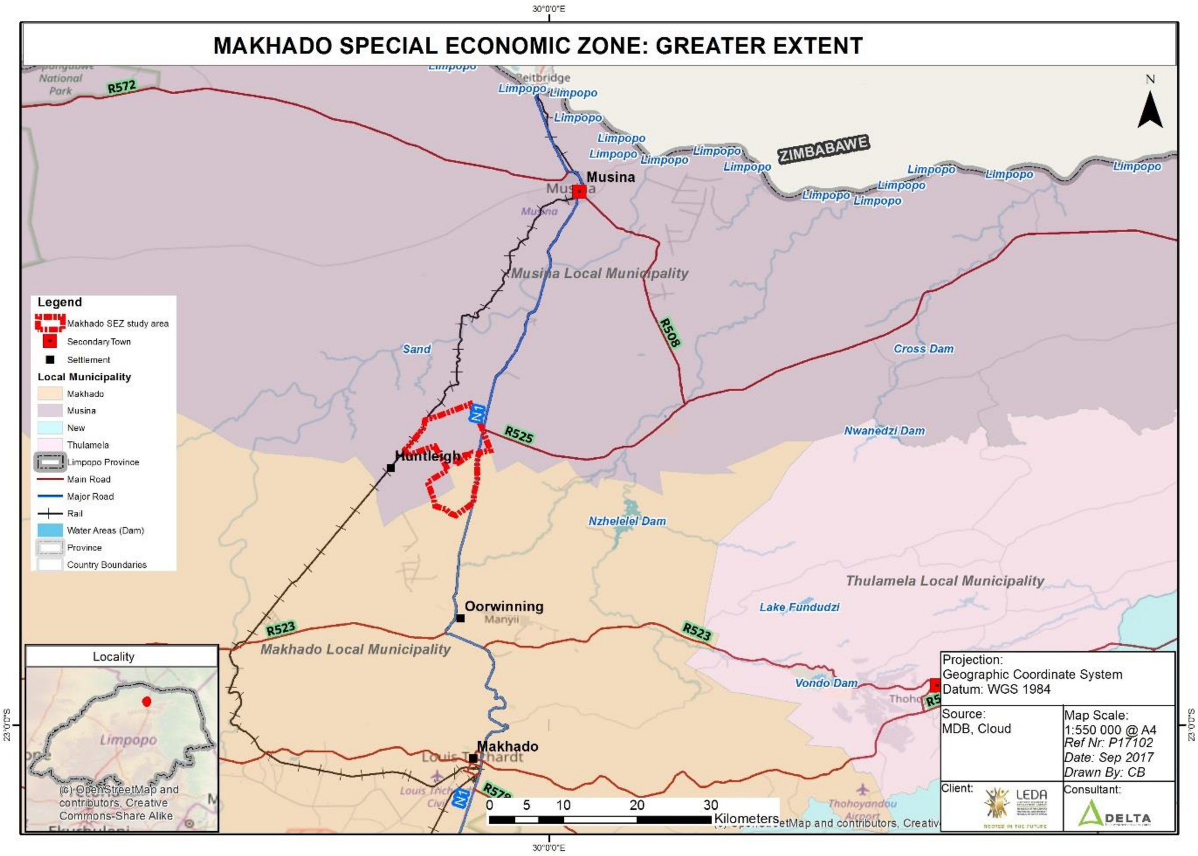

Figure 1: Musina-Makhado Special Economic Zone Proposed Location[4].

2.2.1 Industry capacity and construction phasing

Table 1 indicates the proposed capacity for the different projects comprising the Musina-Makhado SEZ. From this table it is evident that this is a large scale industrial complex which will have varying positive and negative impacts as will be discussed further in this report.

Table 1: Summary of Proposed Projects for SEZ[7]

No.	Project	Total planned capacity
1	Coal washery	20 000 000 tpa
2	Coke plant	3 000 000 tpa
3	Heat recovery power generation	390 MW
4	Thermal power plant	3300 MW
5	Ferrochrome plant	3000 000 tpa
6	Ferromanganese plant	500 000 tpa
7	Silicon manganese	500 000 tpa
8	Vanadium-titanium magnetite	10 000 000 tpa
9	High manganese steel	1000 000 tpa
10	High vanadium steel plant	1000 000 tpa
11	Stainless steel Plant	3000 000 tpa
12	Lime plant	1000 000 tpa
13	Cement plant	2 000 000 tpa
14	Refractories factory	500 000 tpa
15	Sewage treatment plant	140 000 m^3/day
16	Industrial domestic water plant	300 000 m^3/day
17	Light industrial processing zone	Information not provided
18	Machinery zone	
19	Commercial residential area	
20	Living area	
21	SEZ administration centre	
22	Bonded area	
23	Logistics centre	

7 IX engineers, 2019. *EMSEZ – Internal Master Planning*. Lynwood, Pretoria.

The construction phase will cover all leased land and is planned to commence in 2020 pending all required approvals. Table 2 below indicates the timeframes for construction which is anticipated to be complete in 2031.

Table 2: Construction phase timeframes[7]

Project phases	Timeframe	
	Start	End
Early works and internal bulk infrastructure	2020	2021
Phase 1 of plant construction	2022	2026
Phase 2 of plant construction	2026	2029
Phase 3 of plant construction	2029	2031

2.2.2 SEZ water demand

The SEZ comprises various heavy industrial projects which will require a large amount of water for day to day operations. It has been envisaged that the complex will require a feed of 80 million m^3 water annually. Figure 2 below indicate the water balance for the proposed operations.

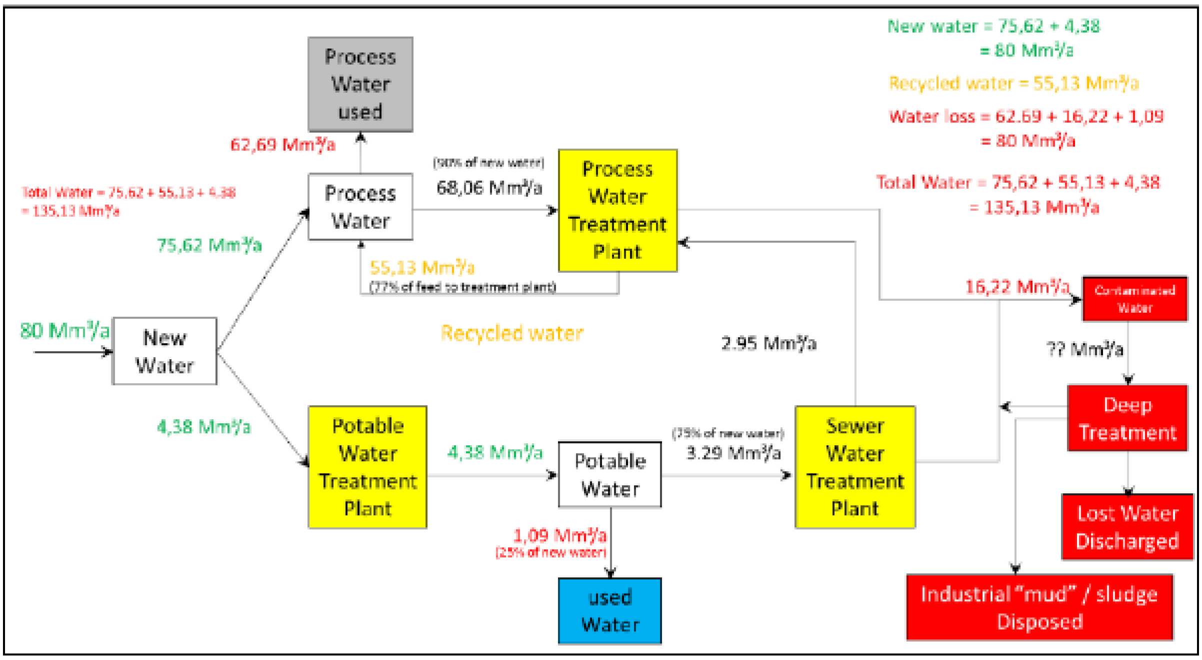

Figure 2: EMSEZ Site water balance[7].

2.2.3 Labour demand

The proposed SEZ envisages to employ 53 800 people. Figure 3 below indicates the employment opportunities for the SEZ.

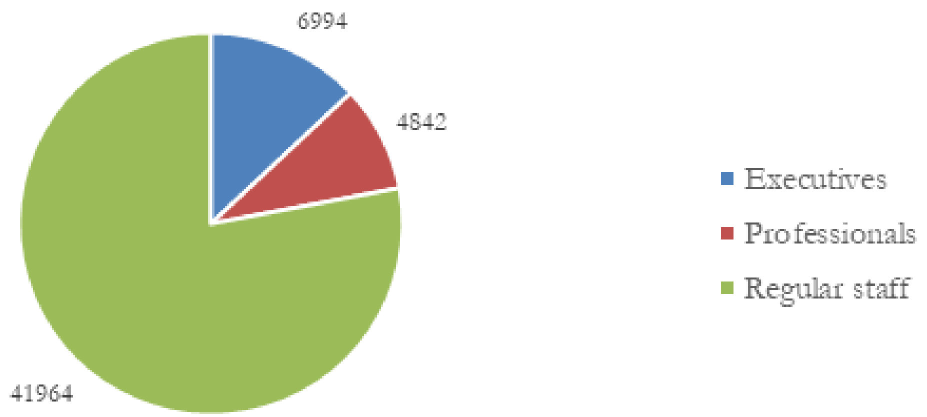

Figure 3: SEZ total labour figures[7].

2.3 Project Setting

The proposed project will impact on the surrounding areas in different ways. The section below describes the environmental setting surrounding the proposed SEZ and the various climate change receptors subject to impacts of the SEZ.

2.3.1 Location

The proposed project will be established on eight farm properties across the Makhado and Musina local Municipalities within the Vhembe District Municipality of the Limpopo Province. The current land use of the site is agricultural. The town of Makhado (located 31 km south) and the town of Musina (located 36km north) are the nearest towns to the proposed SEZ.

2.3.2 Land capability

The proposed SEZ site falls within the Musina Mopane Bushveld which is categorised as least threatened[8] and is regarded as the most diverse Mopaneveld type in South Africa[9]. The land capability of the proposed site is non-arable grazing woodland or wildlife, and wilderness. The soils provide uses for grazing, wildlife management and woodland with limited areas of soil outside the proposed site which are suited to arable agriculture. The historic land cover is indicated in Figure 4 below.

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8 A least threatened or least concern species are those which has been categorised by the International Union for Conservation of Nature as evaluated but not qualified for any other category.

9 Mucina, L, Ruthford, MC 2006. *The Vegetation of South Africa, Lesotho and Swaziland*, Strelitzia 19. South African National Biodiversity Institute Pretoria. Viewed 28 May 2019 https://www.sanbi.org/wp-content/uploads/2018/05/Strelitzia-19.pdf

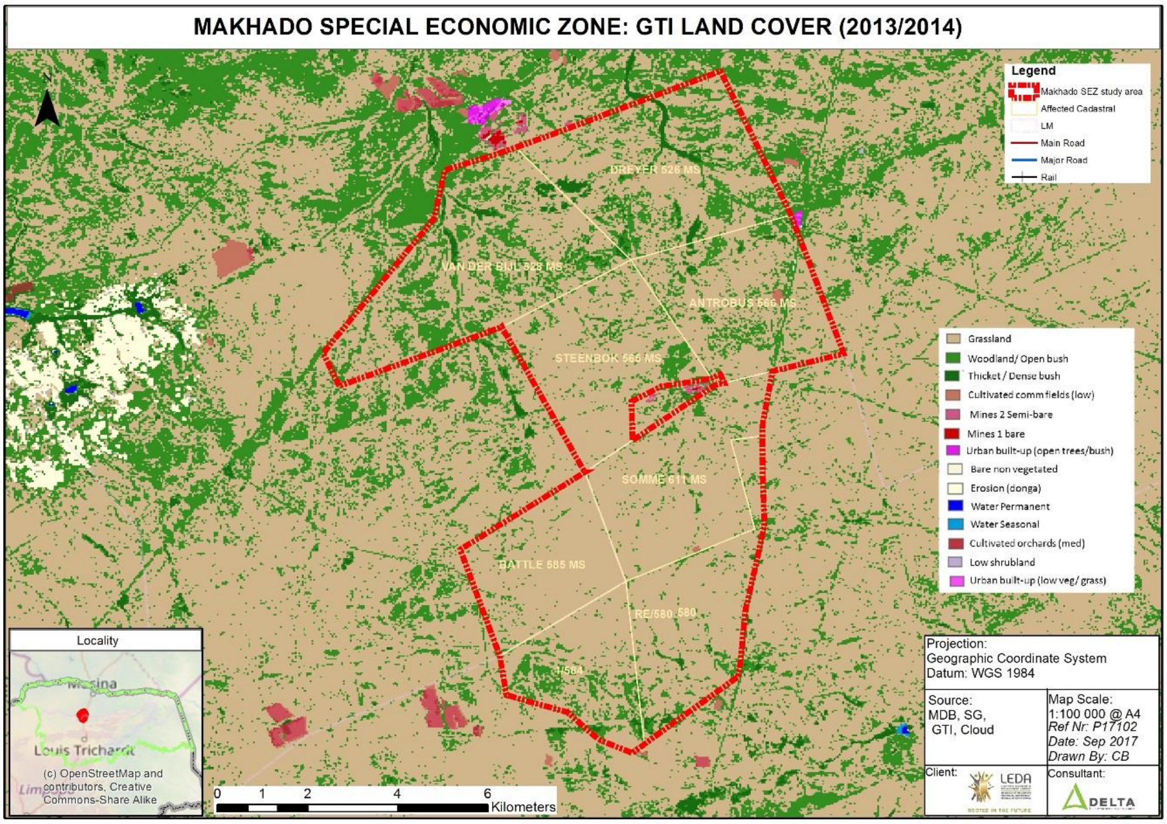

Figure 4: Land cover [4].

2.3.3 Water

It is envisaged that the SEZ will require 80 million cubic metres of water per annum, as indicated in Figure 2 above. Table 3 below shows the current and future water balances of the Musina area. The project team has indicated that a large portion of the water will be sourced from the Limpopo River as well as various water bodies in Zimbabwe. For the construction phase, ground water abstraction has been considered along with abstraction of water from the Limpopo River.

As the Limpopo Water Management Area forms part of internationally shared water basin between Botswana, Zimbabwe, South Africa and Mozambique, international agreements and obligations will have to be made and met as these countries will be impact by the water demand of the SEZ.

Table 3: Current and future water balance of Musina area with interventions [10].

	Interventions	2015	2020	2025	2030	2035	2040
Water Requirements	Musina area Total Requirements (Musina Town and SEZ)	7.96	31.25	65.52	66.83	70.36	73.36
Sources and Interventions	Zimbabwe to South Africa Water Transfer (Beitbridge Water Supply Scheme and other potential sources)	0	0	30	30	30	30
	LEIP Limpopo River abstraction and off-channel storage dam	0	23	23	23	23	23
	Reuse of Musina Treated Effluent	0	2	5	7	7	7
	Limpopo Alluvial Aquifer	10.4	10.4	10.4	10.4	10.4	10.4
Shortfall or surplus		**2.44**	**4.15**	**2.88**	**3.57**	**0.04**	**- 2.96**

Smaller alternative water reserves are the Nzhelele Dam (50km northeast of Makhado) the Sand River and the Mutamba/Nzhelele River, both perennial rivers that flows mainly in winter and situated 10km north and 20km east of the proposed SEZ respectively. Multiple small wetland are scatted across the eight farms with the proposed SEZ falling within the Limpopo Water Management Areas and the Sand Sub-Water Management Area.

2.3.4 Biodiversity

Limpopo has rich biodiversity that forms the basis of a prosperous tourism industry as a result of the Kruger National Park, smaller nature reserves and several luxury private game reserves. It is also home to the Mapungubwe Cultural Landscape, one of South Africa's eight World Heritage sites. Tourism, along with mining, and agriculture has been identified in the Limpopo Development Plan[5] as important sectors to help drive employment and economic growth for the Province.

The SEZ site is located within the Vhembe biosphere reserves of which has three biomes, Savanna, grassland and forest. A number of nature reserves and conservation areas have been established in the Vhembe biosphere which aid in conserving the environment and are presented in Figure 5.

[10] EMSEZ Progress Report Musina 16 July 2019, *RSA/Zimbabwe Water Project, Musina/Makhado SEZ Water Supply*, National Department of Water and Sanitation, Water Resource Planning, Pretoria, South Africa.

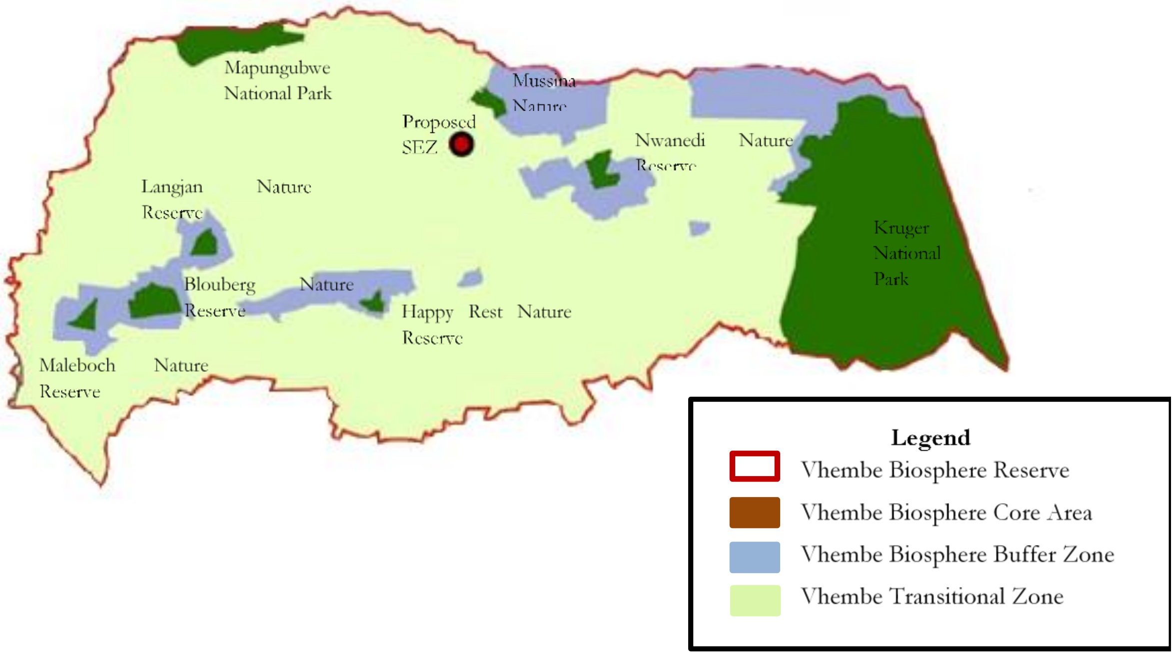

Figure 5: Vhembe Biosphere Reserve[4] .

The proposed SEZ is within an area that is considered a least threatened ecosystem and is surrounded by the Mapungubwe, Soutpansberg and Blouberg Important Bird and Biodiversity areas. The Limpopo Conservation Plan[11] categorizes the northern area in which the SEZ site falls as an Ecological Support Area and indicates this area as occurring in a largely natural state that retains significant importance from a landscape connectivity perspective. The Southern areas of the SEZ proposed site is considered a critical biodiversity areas[2]. Critical biodiversity areas are identified in order to support integrated development planning and sustainable development. Furthermore, they are designed to avoid conflict with existing Integrated Development Plans, Environmental Management Frameworks, and Spatial Development Frameworks in a region by favouring the selection of sites that are least conflicting with other land-uses.

Drought and veld fires have been found to be a key biodiversity threats to the area together with limited supply of ground and surface water due to the increasing demand for water with regards to agriculture, mining and domestic use. Coupled with the fact that existing water resource are being negatively impacted due to pollution as a result of pesticides, poor land management and poorly managed sewerage, climate change is expected to exacerbate these treats to biodiversity[12].

2.3.5 Settlements and surrounding communities

The proposed SEZ is not located within a formal setting as there is low urban development in the immediate surroundings. The nearest formal towns are Louis Trichardt (Makhado) approximately 40km South and Musina approximately 35km north of the proposed SEZ. The following summary

11 Desmet, P. G., Holness, S., Skowno, A. & Egan, V.T. (2013). *Limpopo Conservation Plan v.2*: Technical Report. Contract Number EDET/2216/2012. Report for Limpopo Department of Economic Development, Environment & Tourism (LEDET) by ECOSOL GIS

12 Vhembe District Municipality, 2016. *Vhembe District Municipality Climate Change Vulnerability Assessment Response Plan,* s.l.: s.n.

of informal settlements which are situated in close proximity to the proposed SEZ site indicated below:

- Matsa - 25km South East
- Mopane within proposed location - 1km West
- Mudimeli - 10km South East
- Makushu - 17km East South East
- Bonjane - 18km East
- Numerous farm houses

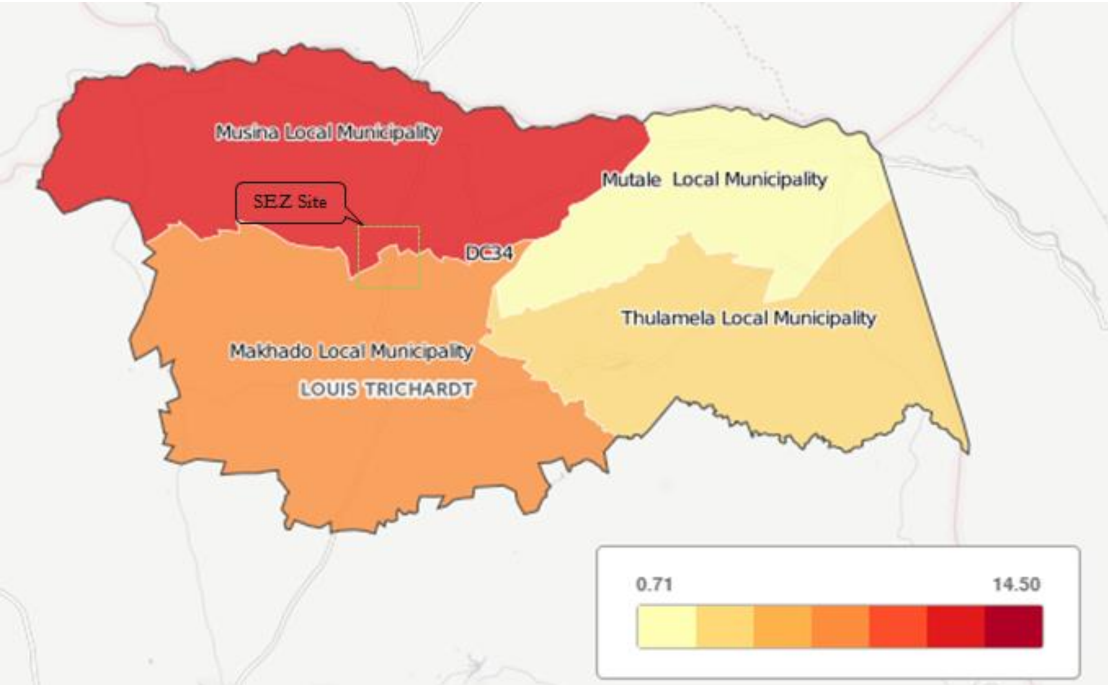

Figure 6: Percentage of households in informal dwellings in the Vhembe District Municipality[12]

The percentage of informal households is illustrated in Figure 6 above indicates higher informal dwellings in the Musina and Makhado local municipalities when compared to the Thulamela and Mutale local municipalities. This highlights the vulnerability of the area due to the fact that poorer regions are impacted more by climate change as they do not have the adaptive capacity to withstand significant disruptions brought forth by variable weather such as droughts and floods.

3 Climate Change Context

3.1 Global Context

Anthropogenic climate change as a global phenomenon is caused by the accumulated greenhouse gas emissions from global emitting sources. The impact thereof on society is increasingly of concern. Recently CO_2 levels surpassed 415 parts per million for the first time in recorded history[13]. Various scenarios have been developed to model climate change impacts for both mitigated (reducing emissions) and unmitigated (business as usual) options.

The receiving environment for this project, in the context of climate change, is the global atmosphere. The duration of the impact of the greenhouse gas emissions is considered as effectively permanent as the greenhouse gas emissions produced 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. The Intergovernmental Panel on Climate Change (IPCC) estimated in the 5th Assessment Report[26] 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 has already been emitted. This leaves a remaining budget, for the period between 2012 and 2100, of 1,010 gigatons of CO_2 before the 2°C limit is breached.

The practical implication of having a carbon budget is that this is the maximum amount of emissions that can be emitted. 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 whole will suffer irreparable damage with dire consequences to the global society.

The Paris Agreement however also states that the world should increase ambition and aim for a target of 1.5°C. This is in order reduce significant and far reaching impacts associated with climate change such as sea rise, desertification, ocean acidification, biodiversity loss and increase in frequency and intensity of extreme weather events. The IPCC reported in 2018 an estimate of the 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 (medium confidence)[14].

The global nature of climate change impacts is such that the greenhouse gas emissions from any individual project or source cannot be connected directly to any specific environmental impacts. The analyses in this report are presented in the context that, even though the individual greenhouse gas emission contribution of a project cannot be directly linked to specific localised climate change impacts, global climate change is nevertheless significant and can be quantified as such. In other

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13 USA Today, *Carbon dioxide levels hit landmark at 415 ppm, highest in human history*, viewed 31 May 2019: https://www.usatoday.com/story/news/world/2019/05/13/climate-change-co-2-levels-hit-415-parts-per-million-human-first/1186417001/.

14 IPCC, 2018. *IPCC, 2018: Summary for Policymakers of IPCC Special Report on Global Warming of 1.5 °C approved by governments,* IPCC, Viewed 31 May 2019: https://www.ipcc.ch/2018/10/08/summary-for-policymakers-of-ipcc-special-report-on-global-warming-of-1-5c-approved-by-governments/

words, the specific greenhouse gas emissions from the proposed SEZ cannot be attributed directly to any particular climate change effects.

Despite this, there is a collective responsibility to address the global challenge of climate change and each actor, such as the proposed SEZ, has an individual responsibility to minimise its own negative contribution to climate change.

3.2 Local Context

The single largest source of GHG emissions in South Africa are coal fired power stations where almost 90% of the country's electricity comes from. This coal intensive energy system has resulted in the country being the 14th largest GHG emitter in the world and thus a significant contributor to global GHG emissions[15]. Coal fired power stations not only contribute to climate change but are also at risk from the impacts and consequences of climate change.

South African is particularly vulnerable to the effects of climate change with regards to the environment as well and the socio-economic context. The variable nature of climate change in terms of increase frequency and intensity of extreme weather events will be consequential for the South African society. Furthermore, South Africa is a water stressed country with predictions indicating future drying, increased droughts and variable and rainfall.

3.2.1 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 in Chapter 5 the NDP. This forms the basis of the following set of goals and action to meet the country's environmental sustainability and resilience needs have been mentioned[16]:

- 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[17] which proposed that climate change be addressed through various interventions that build and sustain social, economic and environment 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 Paris in 2015 sets out the nation's emissions trajectory up to 2050. South Africa's emissions are expected to peak between 2020 and 2025,

[15] Global Carbon Atlas, 2017. http://www.globalcarbonatlas.org/en/CO2-emissions

[16] 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

[17] Available at https://www.gov.za/sites/default/files/gcis_document/201409/nationalclimatechangeresponsewhitepaper0.pdf

plateau for approximately a decade and decline in absolute terms thereafter (the 'peak, plateau and decline trajectory').

South Africa, as a developing nation, requires some 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, the Integrated Resource Plan[18] that a shift to low-carbon electricity generation options will only be possible in the medium term, and not immediately. South Africa is not limiting itself to specific emissions numbers, but the NDC rather provides a peak, plateau and decline trajectory range from the year 2016 (reference point) 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) is expected to make provision for regular updates of this trajectory, through which it can be better placed within the context of the Paris Agreement.

However, 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. In this regard countries such as South Africa must negotiate and determine how to achieve such a target, and how to possibly accelerate efforts to achieve a 1.5°C target through the ratchet mechanism as contained in the Paris Agreement. The ratchet mechanism requires countries to submit new NDCs every five years, outlining how much they intend to reduce emissions. Each submission should be more ambitious than the last. South Africa's NDC has been assessed as insufficient to meet a 2°C target. 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 projects such as the proposed SEZ.

In addition to the NDC, the base case of South African draft updated Integrated Resource Plan (IRP)[18] incorporates the CO_2 emissions constraints as guided by the country's peak, plateau and decline trajectory. The draft updated IRP applies the moderate decline annual constraints as an instrument to reduce national emissions, which is in line with government policy to reduce greenhouse gas emissions. Government's policy might change in the future, as per the developments of the Department of Environmental Affairs mitigation system and proposed Climate Change Act. A process is currently being undertaken by the 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.

3.2.2 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 in a per capita basis. The

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

national population figure for South Africa is 58 million people[19]. If this is taken as a percentage of the global population of 7.7 billion people[20], then South Africa's carbon budget is approximately 7,572 Mt CO_2e. The evaluation of the impact of the SEZ on this **limited resource** will therefore be done by considering its contribution to South Africa consuming its carbon budget.

3.2.3 Local climate change impacts

Despite the global and national commitment to limiting global temperature increase to 2 °C, the NDCs of all countries combined cover only approximately one third of the emission reductions needed to achieve this goal. Therefore, there will be significant climate change impacts affecting South Africa, and thus the proposed SEZ, regardless of whether the global community implements the NDCs. As a consequence, while the impact of the SEZ on climate change may be small, the impacts of climate change on the SEZ could potentially be large.

Risks resulting from climate change impacts may include increasing land-surface temperatures, increasing rainfall variability, decreasing overall rainfall, as well as increasing frequency and intensity of extreme weather events. These risks relate to:

- Decreasing water availability and quality may negatively affect the SEZ's direct operations as well as the upstream and downstream value chain;
- Damages to infrastructure which could disrupt operations, transport of goods and lead to increased risk of injury;
- 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;
- Declining air quality may impact on the issuance or conditions of issuance of air quality licences for operations in the SEZ;
- Disruption to commerce, critical infrastructure and developments, transport systems and traffic by extreme rainfall events and flooding will impact on the SEZ's ability to operate;
- Increased number of power outages, water supply and transport disruptions; and
- Increased risk of infectious, respiratory and skin diseases, water- and food-borne diseases.

3.2.4 Pathways for a just transition for the Province of Limpopo

The National Planning Commission (NPC) is currently aiming to build a consensus on a vision and pathway for an equitable and sustainable South Africa in 2050 through the National Development Plan's, Pathway for a Just Transition. The NPC has agreed that climate change is an urgent and cross cutting issue and will be addressed in all chapters of the NDP. The following

[19] Stats SA, 2018. *Mid-year population estimates 2018*. Viewed 31 May 2019 http://www.statssa.gov.za/?p=11341

[20] Worldometers, 2019. *Current world population*. Viewed 31 May 2019 http://www.worldometers.info/world-population/

challenges and issues were identified through the pathway for a just transition workshops conducted by the NPC[21];

- Lack of awareness about climate change and environmental factors;
- Lack of buy-in from management to enact climate change solutions;
- Poor planning with regards to future climate change implications. Municipalities do not investigate what the current weather and future climate impacts will be and as a result settlements are situated on climate vulnerable areas such as flood lines; and
- The need to for strong education and awareness campaign around the impacts of climate change and land-use alongside a capable state.

Climate change management should therefore not be limited to emissions reductions (mitigation) and should focus on adaptation measures as well. Identifying impacts of climate change on the project will therefore be considered in this assessment, which can inform the SEZ's design, development and closure/rehabilitation strategies to reduce risk exposure and ensure long-term sustainability.

3.3 Observed Trends and Projected Climate Change

3.3.1 National overview

The impacts of climate change on South Africa have been summarised in the Department of Environmental Affairs' *Long Term Adaptation Scenarios* (LTAS) study[22]. 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*[23].

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[24]. This had impacted 21 million people and claimed the lives 1,692 people in the country[25]

Furthermore, South Africa is expected to experience high population and urbanisation growth in the next thirty years which emphasises the impacts of an increase in the frequency and intensity of

[21] The Department of Planning, Monitoring and Evaluation, *National Development Plan: Pathways for a Just Transition Limpopo Stakeholder Dialogue Meeting* 3 April 2019, Polokwane, Limpopo.

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

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

[24] 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.

[25] CRED (Centre for Research on the Epidemiology of Disasters). 2018. EM-DAT: CRED/OFDA International Disaster Database. Brussels: Université Catholique de Louvain. [Online] Available at: http://emdat.be/emdat_db/.

extreme weather event on settlements due to a growing exposure to the high socio-economic vulnerability[24]. With an increase in population expected, more people in these areas are exposed and impacted.

Air temperatures in South Africa have increased at least 50% more than the global annual average of 0.65 °C over the last five decades. 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[26]. This indicates that in a world of more than 2°C average temperature change, South Africa could experience changes of over 3°C.

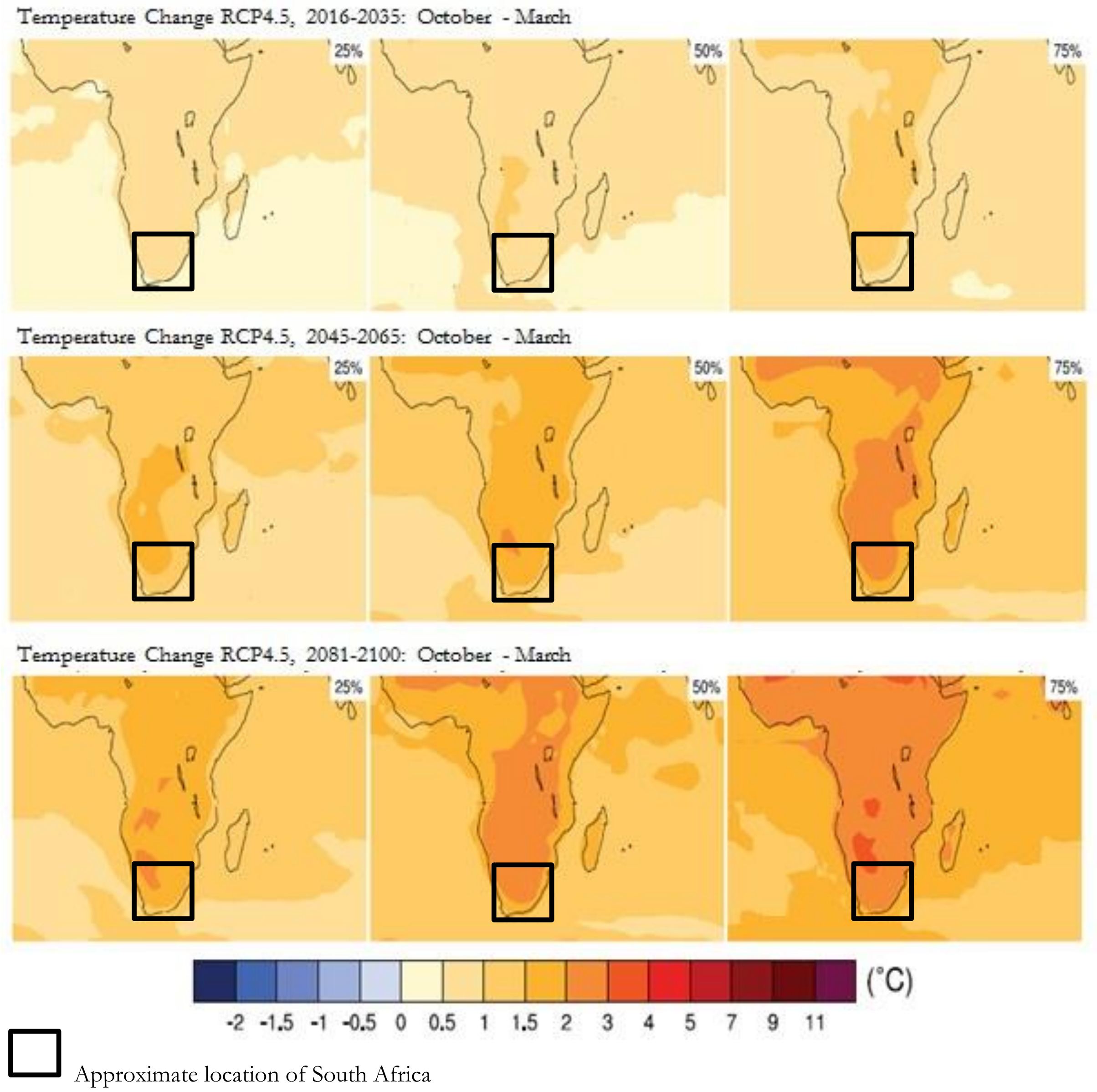

Figure 7: Projected Southern African temperature change under RCP4.5[26].

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

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 Figure 8 below 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 societal 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 erodes the adaptive capacity of these communities to climate change, rendering them increasingly vulnerable.

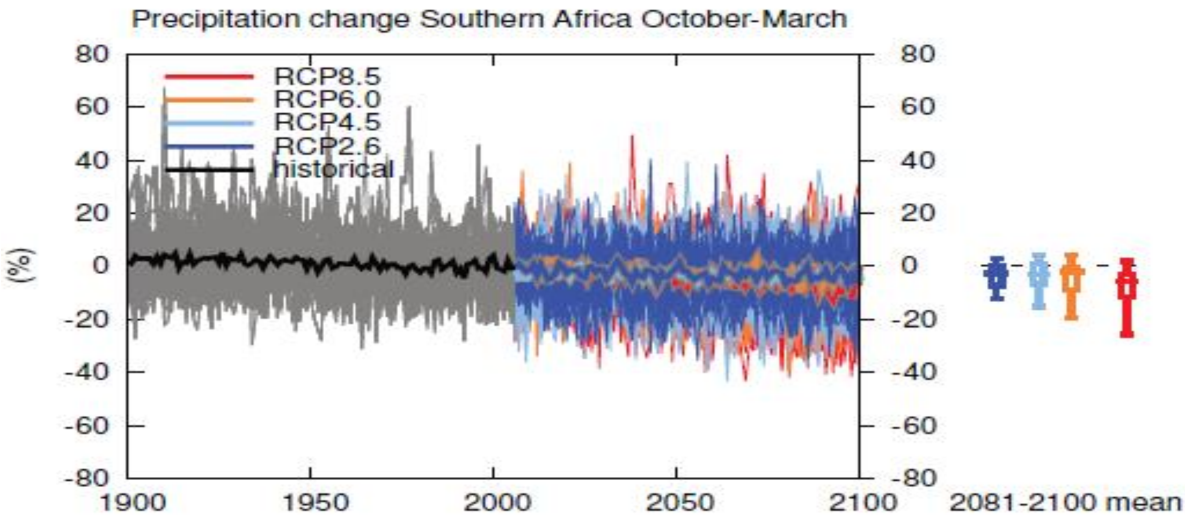

Figure 8: Projected global surface temperature change under different emissions scenarios[26]

3.3.2 Provincial overview

The two most significant climate change projections in the Province are increases in average temperatures and rainfall variability. The Limpopo Province is likely to experience regular droughts and heat intensity, water shortages, and possible diseases spreading related to the chases in climatic conditions which will have adverse effects on the economy, natural resources, infrastructure, human health and community livelihoods.

The projected changes as a result of climate change in Limpopo are[12]:

- Regular droughts and heat intensity;
- Water shortages;
- An increase in natural disasters such as floods and fires;
- Shifts in species and localisation of species;

- Migration of rural populations;
- Contamination of ecosystems from water and waste pollution; and
- Increases in communicable and non-communicable diseases in urban and rural areas

3.3.2.1 Temperature

The Limpopo province is highly vulnerable to climate change, with South Africa's LTAS suggesting that the Limpopo province could face a potential increase in temperatures by as much as 2 °C by 2035 with further temperature increase forecasted by as much as 6 °C to 7 °C between 2080 and 2100[5].

Mean temperature ranges between 20 - 22˚C for Makhado and with Musina experiencing hotter conditions with mean temperature ranges of 24-26˚C. The area in which the SEZ is proposed to be located indicates tendencies for drought as well as experiencing elevated temperatures (very hot days) of over 35˚C between 60 and 90 days a year. Figure 9 below shows the projected drought tendencies for the period 1995-2024, relative to 1986-2005 baseline period, under low mitigation scenario (RCP 8.5). A negative value indicates an increase in drought tendencies per 10 years.

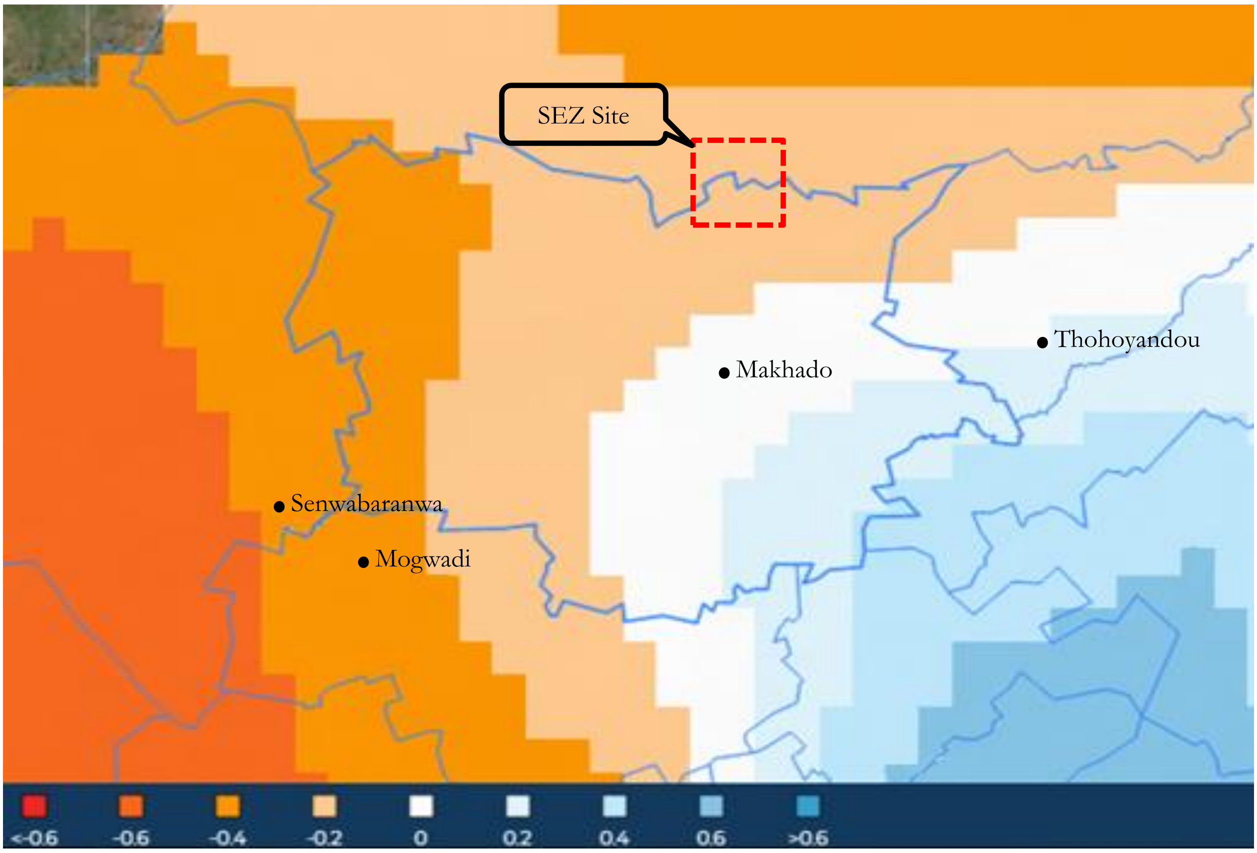

Figure 9: Limpopo drought tendencies for the period 1995-2024[27].

[27] 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.

Temperature related climate change impacts include crop loss due to extreme weather conditions and the spread of pests into new areas as temperatures become more favourable. In an area where rural communities depend on cultivating their own crops, changing temperature patterns might cause a decline in rural farming and annual harvests, jeopardising sufficient food levels for these communities. Furthermore, an increase in average temperature levels associated to climate change might have an adverse effect on the SEZ's labour force as employees work outdoors will therefore be particularly vulnerable to increases in temperature. Consequently, the rising temperatures may pose health hazards, reduce labour productivity, and worsen air quality conditions within SEZ.

3.3.2.2 Rainfall and water

In the case of the proposed SEZ, water is considered from a regional perspective as climate change impacts related to water do not only affect the source of water directly related to the SEZ but also the water areas surrounding the site. It is therefore, extremely important that both surface and ground water studies be conducted to delineated availability, capacity and future balances as a result of the water demand for the SEZ as well as the water demand of a growing population within the Musina and Makhado municipalities.

Rainfall averages 588mm per annum in Makhado and decreases moving north towards Musina which has an average of 426 mm per annum. For both these areas the majority of the rainfall falls in the summer months of October through to January. The proposed SEZ site is located within a low to medium flooding hazard with areas approximately 25km South and South East of the proposed SEZ site being indicated as high to very high flood hazards. Figure 10 below shows the flood Hazard index of the different quinary catchments present or intersecting with the municipality. The flood hazard index is based on the catchment characteristics and design rainfall, average at the quinary catchment level.

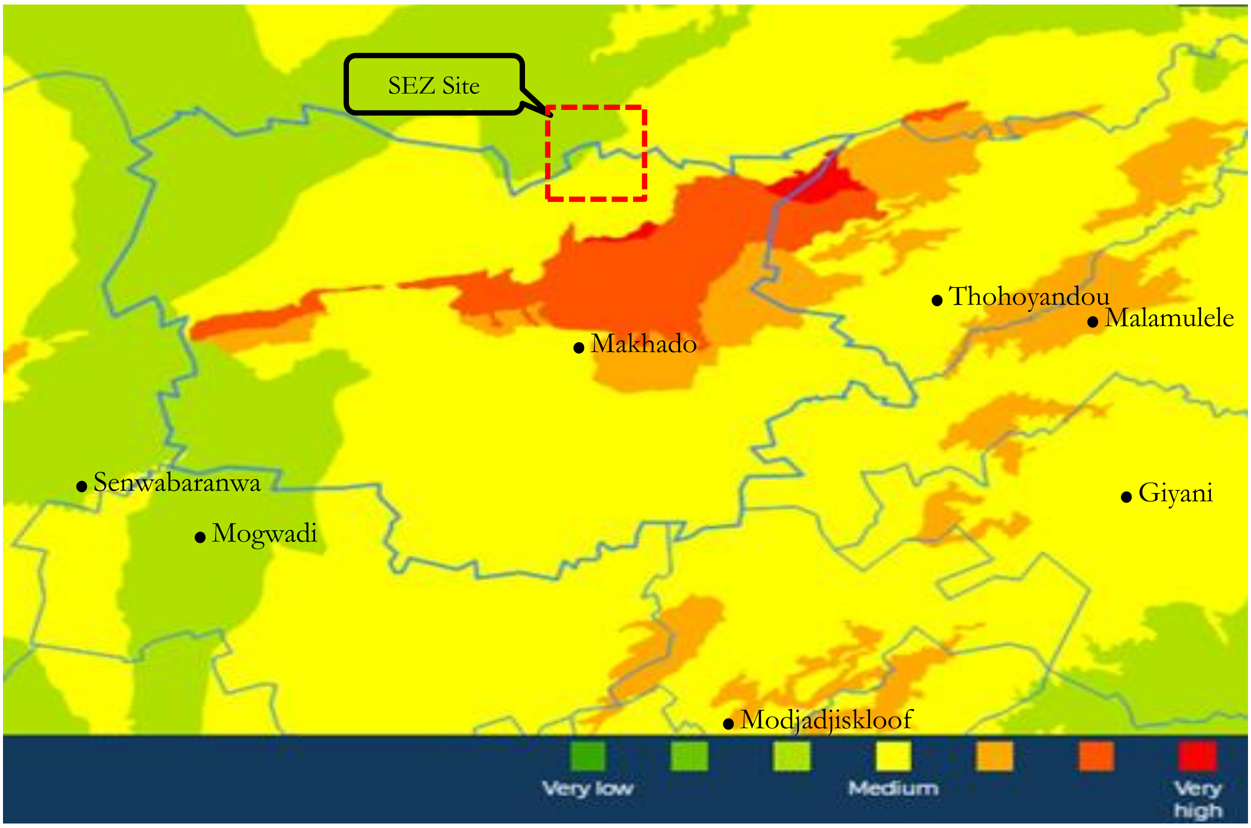

Figure 10: Flood Hazard index[27].

Rainfall projections for the Limpopo Province show levels of uncertainty however, evidence suggests decreases in annual rainfall[22]. The combination of significantly increased temperatures and lessened rainfall will contribute to an increase in evaporation rates, further implying a drier future despite the possibility of periodic heavy rainfall events. The current and projected climatic variability will greatly impact on Limpopo's water supply and quality provision, which could in future constrain the province's economic growth. This is specifically relevant in the provincial context of the proposed SEZ as the Limpopo province is already vulnerable to droughts and variable rainfall patterns. Water intensive sectors, such as energy and metallurgical industries that will be located in the SEZ could face major operational challenges.

3.3.3 Municipal overview

The proposed SEZ falls on the boarder of the Musina and Makhado Local Municipality, located in the Vhembe District Municipality. Vhembe District Municipality comprises four local municipalities namely;

- Makhado Local Municipality (population 516,031);
- Musina Local Municipality (population 68,359)
- Thulamela Local Municipality (population 618,462); and
- Mutale Local Municipality (population 91,870)

District has a total population of approximately 1,294,722[28]. It has a high unemployment rate of 24.9% with 50.8% not economically active and only 21.26% of the population having a matric certificate [12].

During 2016 the Vhembe District Municipality developed a Climate Change Vulnerability Assessment and Response Plan to address the threats posed by climate change on sustainable development. Key climate change vulnerability indicators were identified as part of the District's climate change assessment. The relevant indicators within the context of the project location and scope are summarised in the following table:

Table 4: Vhembe District Municipality key climate change vulnerability indicators[12].

Theme	Indicator Title	Exposure	Sensitivity	Adaptive Capacity
Agriculture	Reduced food security	Yes	High	Medium
	Change in grain (Maize, wheat & barley) production	Yes	High	Low
Biodiversity and Environment	Loss of Grasslands	Yes	High	Medium
Human Health	Health impacts from increased storm events	Yes	High	Low
	Increased heat stress	Yes	High	Low
	Increased vector borne diseases from spread of mosquitoes, ticks, sand flies, and blackflies	Yes	High	Medium
	Increased water borne and communicable diseases (typhoid fever, cholera & hepatitis)	Yes	High	Low
	Increased malnutrition and hunger as a result of food insecurity	Yes	High	Medium
	Increased air pollution	Yes	Low	-
	Increased Occupational health problems	Yes	High	Low
Human Settlements, Infrastructure and Disaster Management	Increased isolation of rural communities	Yes	High	Medium
	Increased migration to urban and peri-urban areas. Note that climate change impacts in other areas in South Africa, as well as its neighbouring	Yes	High	Low

[28] Stats SA, 2018. *Popoulation Limpopo, 2019.* Viewed 3 June 2019 Available at: http://www.statssa.gov.za/?page_id=964

Theme	Indicator Title	Exposure	Sensitivity	Adaptive Capacity
	countries can cause migration to SDM			
Water	Less water available for irrigation and drinking	Yes	High	Low
	Decreased water quality in ecosystem due to increased concentrations of effluent and salt concentrations	Yes	High	Low

Additionally, Agriculture, Forestry and Fisheries (AFF) contributes 13.76% to total employment in the Makhado municipality and 0.7% to the national AFF Gross Value Add (GVA). Musina AFF contributes significantly more jobs (36%) to the area, and yet contributes less (0.52%) to the national AFF GVA. As indicated in the above table, the Vhembe District municipality has a low adaptive capacity with regards to impacts of climate change on agriculture. This threatens the sustainable development of the district which relies on AFF for employment.

Furthermore, the South African online planning tool, the Green Book, provides quantitative scientific evidence on the likely impacts that climate change and urbanisation will have on South Africa's cities and towns. The Green Book has quantitatively rated all South African municipalities using multi-dimensional vulnerabilities such as socio-economic, economic, physical and environmental. Musina and Makhado are rated 195 and 168 respectively out of 213 municipalities (higher rating indicates higher vulnerability) in South Africa in terms of environmental vulnerability, an indicator representing the conflict between preserving the natural environment and accommodating the growth pressures associated with population growth, urbanisation and economic development. This again emphasizes the vulnerability of the municipalities to the disrupting effects of climate change and further highlights the need for careful consideration of the climate change implications that constriction of large industries could impose on the municipalities' resource dependency.

3.4 Other Potential Climate Change Dimensions Relevant to the SEZ

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;

- Increasing humanitarian demands, as climate change impacts are experienced.

South Africa, and the Limpopo Province, has an economically divided society due to a number of socio-economic disparities. As a result, its population is characterized by a vulnerable majority. The vulnerable majority is more exposed to climate change impacts and may pose risks to large industrial developments such as the SEZ, either through migration of workforces or increased humanitarian demands.

4 Methodology

4.1 Impacts of the Project on Climate Change

The following subsections outline the methodology used to assess the impacts the Musina-Makhado SEZ development will have on greenhouse gas emissions. The results of the carbon footprint calculations and the assessment of its environmental impacts are presented in section 6 of this report.

4.1.1 Greenhouse gas emissions estimation methodology

The emissions calculated in this report consider the emissions from activities envisioned as part of the SEZ. An umbrella approach was followed for the SEZ which considered the emissions of the SEZ in its entirety. This report assumed that an Environmental Impact Assessment (EIA) and related climate change impact assessment, including establishing a greenhouse gas inventory, will be completed for each of the proposed activities within the SEZ.

As the designs for the various activities and related plants envisaged for the SEZ, as listed in Table 1 above, has not yet been finalised, the emissions for each of these plants cannot yet be calculated. Therefore, this assessment has determined emission intensities for the various activities envisioned within the SEZ (based on available information), required to achieve national and international climate change objectives. These intensities should serve as suggested benchmarks to guide and inform the environmental authorisation processes related to each of the activities to take place within the SEZ.

This methodological approach is illustrated in the following figure:

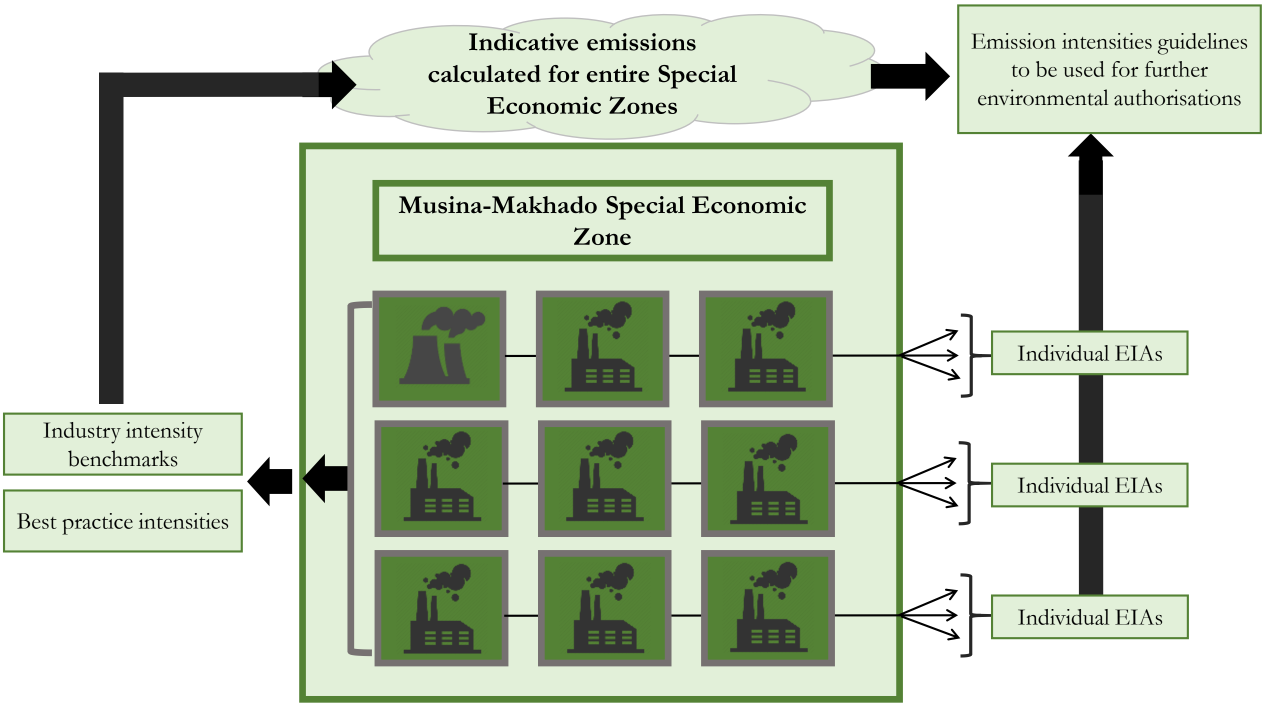

Figure 11: Proposed Methodology boundary and input

The calculation of the various emission intensities was a 2-step process:

Step 1: Historic and current best practice emission intensities were determined. These emissions were calculated making use of industry benchmarks and carbon emission intensities published in the "*GHG Emissions Intensity Benchmarks for South Africa's Carbon Tax*" prepared by Ecofys for National Treasury. This formed the starting point of the assessment.

Step 2: The second step was to contextualise the emission intensities in relation to national and international targets and commitments. In this regard, South Africa's Nationally Determined Contribution (NDC) to the Paris Agreement, as well as the 2018 IPCC 1.5°C Special Report was used. The NDC allows for a Peak Plateau and Decline (PPD) trajectory for South Africa, whereas the IPCC 1.5°C Report goes further and proposes that the world as a whole should have net-zero emissions by 2050. It was assumed that the various activities envisioned as part of the SEZ will be operational by 2030.

The plants associated with the various activities in the SEZ will be operational under intense emission reduction pressure, both locally and globally. From a global perspective, in order to achieve a 1.5°C temperature target, the emissions from the plants should reach zero over their expected lifetime. Locally, South Africa's NDC commitments requires significant emission reductions from 2035 onwards. The intensity methodology thus assumes that the intensity the plant will be built with would represent its emission intensity for at least the first ten years of its operating life. In this respect, individual plants/activities should meet the suggested 2030 emission intensities as part of their respective environmental authorisation processes.

This analysis used an internationally accepted methodology to estimate what the emission intensities by 2030 should be, for a 2°C target, as developed by the Science Based Target Initiative (SBTi)[29].

Detailed information is not yet available for the construction phase for each of the individual plants. As mentioned, it is assumed that an EIA and related climate change impact assessment will be completed for each of the applicable activities within the SEZ. During such an assessment, it is assumed that the required level of detailed data will be made available which can be used to calculate the emissions associated with the construction and decommissioning phases of each of the activities. Due to the nature of the various activities envisioned for the SEZ, these plants will have high process emissions during the operational phases. Compared to the process emissions, it is expected that the construction and decommissioning phase emissions of the plants will be insignificant. Nevertheless, it is important that the impacts of climate change are considered in the decommissioning and rehabilitation plans within each of the separate EIAs.

The South African Greenhouse Gas Reporting Technical Guideline prescribes that direct emissions be considered for mandatory greenhouse gas reporting. The intensity methodology applied to this study considers the various direct emissions from the various planned activities within the SEZ. As such this methodology meets South Africa's Greenhouse Gas Reporting regulations.

Following the above, the calculation of the emissions were done as indicated in sections 4.1.1.1 and 4.1.1.2 below.

4.1.1.1 Historic and current emission intensity benchmarks

The intensities presented in Table 5 below are presented in tonnes of carbon dioxide equivalent (tonne CO_2e) per tonne of output product. The intensities include both Scope 1 and 2 emissions.

Table 5: Emission intensity benchmarks used

Plant	Value	Unit	Reference
Coke plant	0.3 - 0.5	t CO_2e/t product	GHG Emissions Intensity Benchmarks for SA Carbon Tax - Ecofys
Ferrochromium plant*	4.49	t CO_2e/t product	GHG Emissions Intensity Benchmarks for SA Carbon Tax - Ecofys
Ferromanganese plant*	4.49	t CO_2e/t product	GHG Emissions Intensity Benchmarks for SA Carbon Tax - Ecofys
Pig iron plant	1.4-1.7	t CO_2e/t product	GHG Emissions Intensity Benchmarks for SA Carbon Tax - Ecofys

29 https://sciencebasedtargets.org

Plant	Value	Unit	Reference
Carbon steel plant	0.6 - 0.7	t CO_2e/t product	GHG Emissions Intensity Benchmarks for SA Carbon Tax - Ecofys
Stainless steel plant	1.11	t CO_2e/t product	Energy Use and Carbon Emissions in the Steel Sector in Key Developing Countries
Lime plant	1.092	t CO_2e/t product	A competitive and efficient lime industry, cornerstone for a sustainable Europe (2014)
Cement plant	1.0	tCO_2e/t clinker	Benchmarking study conducted by Promethium Carbon
Silicon- manganese plant	6.9	t CO_2e/t product	LCA - Environmental profile of manganese alloys: International Manganese Institute
Sewage treatment plant	0.000708	t CO_2e/t water	DEFRA 2018
Water treatment plant	0.000708	t CO_2e/t water	DEFRA 2018

* These intensities were adjusted to align with an energy intensity of 3.5MWh/tonne. This value was obtained from consultations with an international ferroalloy expert.

4.1.1.2 Emission intensities for a 2°C target by 2030

The Sectoral Decarbonisation Approach (SDA) method of the Science Based Target Initiative (SBTi) is based upon trajectories for specific sectors. The SDA method projects that the global production of crude steel will increase to 2.295 Mt by 2050. This is an increase of 55% on 2010 production levels of 1.482Mt. Despite this increase in demand, the SDA requires that a reduction of 31% in total emissions from the Iron and Steel sector is required in order to meet a 2°C target (Science Based Targets Initiative, 2015).

The SBTi has published a tool for calculating targets based on the SDA approach as well as the absolute contraction approach. This tool has been used to calculate the emissions intensity the plants should have in 2030 to align with the 2°C target trajectories. In the calculations it was assumed that the benchmark intensities used in the carbon footprint would be applicable to the plant in 2020. It is also assumed that the production output capacity remains the same going forward. Where there was no applicable SDA sector then the Absolute Contraction Method was used.

The resulting intensities can be seen in the table below. The target trajectories for the pig iron and carbon steel plants can be seen in the figure below. The pig iron and carbon steel plants were combined to align with the SDA sector definition.

Table 6: Emission intensities required to achieve the Paris Agreement 2°C goal

Plant	2°C target intensities for 2030
Coke Plant	0.21 tCO_2e/tonne product
Ferrochrome plant	3.37 tCO_2e/tonne product
Ferromanganese plant	3.37 tCO_2e/tonne product
Silicon-manganese plant	5.18 tCO_2e/tonne product
Carbon steel plant	0.37 tCO_2e/tonne product
Stainless steel plant	0.78 tCO_2e/tonne product
Lime plant	0.87 tCO_2e/tonne product
Cement plant	0.80 tCO_2e/tonne clinker
Sewage treatment plant	0.0005 tCO_2e/tonne water
Water treatment plant	0.0005 tCO_2e/tonne water

4.1.2 Environmental impacts of greenhouse gas emissions

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

Table 7: 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, and a value between 1 and 5 will be assigned as appropriate (with 1 being low and 5 being high). In the case of climate change assessments, the extent is always global, and thus a 5 is allocated to all projects that contribute to global anthropogenic climate change.
Duration (D)	An indication of the lifetime of the impact quantified on a scale from 1-5. Impacts with durations that are; very short (0–1 years) are assigned a score of 1, short (2-5 years) are assigned a score of 2, medium-term (5–15 years) are assigned a score of 3, long term (> 15 years) are assigned a score of 4 or permanent are assigned a score of 5. In the case of climate change assessments, the duration is always long term, and thus a 5 is allocated to all projects that contribute to global anthropogenic climate change.
Magnitude (M)	An indication of the consequences of the effect quantified on a scale from 0-10. A score of 0 implies the impact is small, 2 is minor, 4 is low and will cause a slight impact, 6 is moderate, 8 is high with sizable changes, and 10 is very high resulting drastic changes. The context within which the environmental impact assessment reporting requirements were

<table>
<tr><td></td><td>developed to describe and assess environmental impacts, however greenhouse gas emissions that have a global impact has yet to be described. For this reason, a materiality threshold was defined. South Africa's carbon budget is described in 3.2.2 above. The following impact ratings have been identified as a means of benchmarking greenhouse gas inventories, over the lifetime of the specific activity, related to emissions that occur within the boundaries of South Africa.

Table 8: Greenhouse gas emissions impact rating
<table>
<tr><th></th><th>Greenhouse gas inventory</th><th>% of South African carbon budget</th></tr>
<tr><td>South Africa's carbon budget based on proportion of local population</td><td>7,572 $MtCO_2e$</td><td></td></tr>
<tr><td>Low impact by project – emissions up to:</td><td>10,000 tCO_2e</td><td>0.00013%</td></tr>
<tr><td>Medium: impact by project – emissions up to:</td><td>1,000,000 tCO_2e</td><td>0.013%</td></tr>
<tr><td>High: impact by project – emissions up to:</td><td>10,000,000 tCO_2e</td><td>0.13%</td></tr>
</table>
The magnitude of a project is considered high if the emissions are equivalent to 0.13% of the South African carbon budget and low if they fall below 0.00013% of the South African carbon budget.</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. 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>

4.2 Impacts of Climate Change on the Project

The impacts of climate change on the project is assessed for two reasons. Firstly, the analysis is intended to establish whether or not the project has sufficiently considered the effects of climate change in terms of its design. This is important, as the EIA considers the impact of the 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. Secondly, the impact of climate change on the project is considered as it relates to the guidance provided by the judgement in the Thabametsi Case[30].

[30] 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

The potential impact of climate change on the SEZ 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[31].

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 SEZ's core operations, value chain and the broader network. This approach is in line with guidance from the International Council on Mining and Metals.

- The core operations include activities taking place within the operational functioning of the SEZ.
- The value chain includes the upstream goods and services, as well as the downstream use of product.
- The social context of the proposed SEZ in terms of the climate vulnerability; and
- The natural environment with regards to climate impacts.

By identifying the levels of exposure, sensitivity, potential physical and transitional risks and adaptive capacity, it can be assessed whether and to what extent the SEZ's core operations, value chain and broader social and natural environment are vulnerable to climate change. The following figure provides a schematic overview of the approach to the vulnerability assessment.

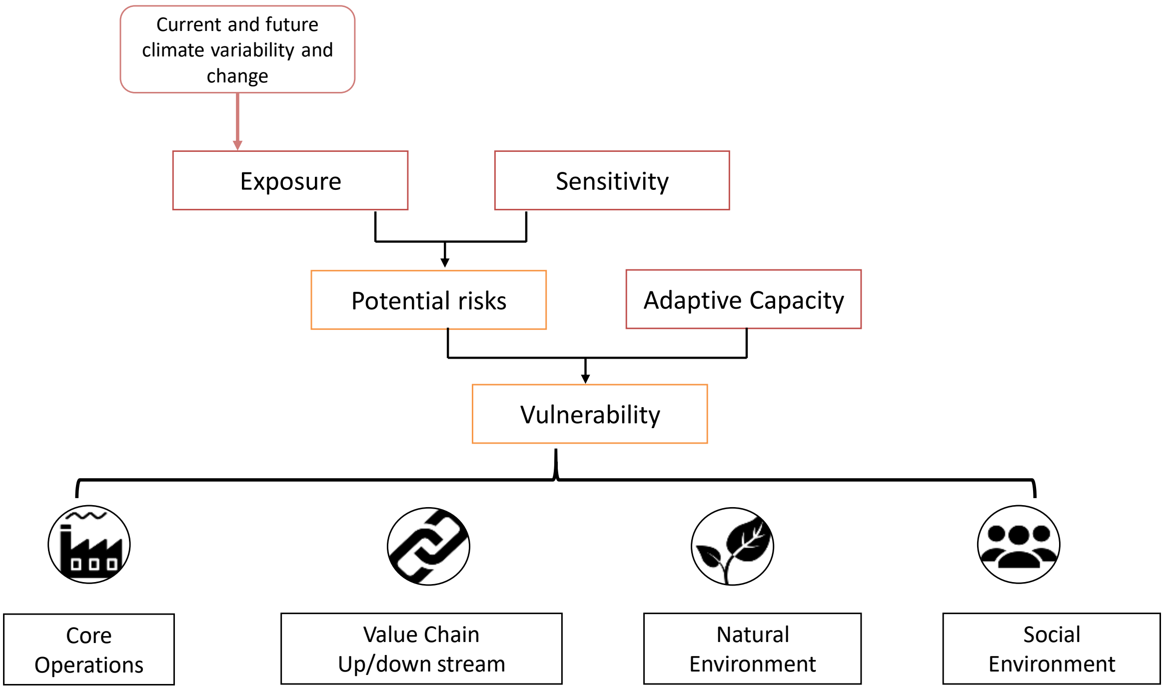

Figure 12: Vulnerability assessment process

31 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.

The vulnerability assessment considers the core operations of the proposed project, the project's value chain as well as the social and natural environment which could impact the project or be impacted on by the project.

Exposure refers to what extent a system is being subjected to climate factors (e.g. temperature, precipitation). To which degree a system or group is positively or negatively affected by climate change exposure is defined by *sensitivity*. Only factors that directly impact the climate (change) are considered sensitivities. *Risks* are identified based in the climatic parameters identified in the describing the receiving environment, and how exposed and sensitive the project is in relations to these climatic changes. *Adaptive capacity* refers to "a set of factors which determine the capacity of a system to generate and implement adaptation measures" (GIZ 2014, p. 24) which is relevant to the project's core operations.

Once all of these elements have been assessed, the vulnerability of a specific project can be defined. Vulnerability is indicated as high, medium or low, as defined by the following table.

Table 9: Musina Makhado SEZ Climate Change Risk and Vulnerability Analysis Components

Risk analysis component	Legend and definition	
High risk		High risk implies a high likelihood of the identified MM SEZ risk being worsened / exacerbated under a high or a low mitigation scenario. It also suggests a high impact of the risk under a high or a low mitigation scenario. For example, a shut-down of the operations.
Medium Risk		Medium risk implies a likelihood of the identified MM SEZ risk being continued under a high or a low mitigation scenario which is still material to the SEZ's core operations, value chain and the broader community.
Low Risk		Low risk implies a lower likelihood of the identified MM SEZ risk being worsened / exacerbated under a high or a low mitigation scenario. It also suggests a lower impact of the risk under a high or a low mitigation scenario to the SEZ.

Climate change-related risks were divided into two major categories, namely physical risks and transitional risks. This follows the Task Force on Climate-Related Financial Disclosures' (TCFD) new, only recently published, direction around standardised assessment and reporting of climate change risks.

The TCFD defines physical and transitional risks as follows:

- **Physical risks**: Physical climate change risks can be event driven (acute) or can be longer-term shifts (chronic) in climate patterns. Physical risks may have financial implications for the proposed SEZ, such as interruption of operations, direct damage to assets and indirect impacts from supply chain disruption.
- **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 SEZ.

The risks are classified as either low or high depending on the emissions scenario. Physical risks are higher and regulatory risks are lower under the climate change scenario related Concentration Pathway (RCP) 8.6 scenario (unmitigated emissions scenario), as this scenario is expected to increase global temperatures by 6 °C which would for example increase the risk of heat stress.

Typically, physical risks are lower and regulatory risks are higher under the climate change scenario related to the Nationally Determined Contribution or a Representative Concentration Pathway (RCP) 2.6 scenario (mitigated emissions scenario), as this scenario aims to keep temperatures at 2 °C or below. The mitigated emissions scenario is supported by the Paris Agreement and will be achieved as countries set ambitious Nationally Determined Contributions (NDCs). As country's work towards their NDCs, additional regulations may be put in place to limit emissions from fossil fuel intensive industries or encourage renewable energy development.

5 Impact of Project on Climate Change

5.1 Quantification of the Project's Greenhouse Gas Emissions

A greenhouse gas emission indicator report was provided by the client and the emissions contained therein are summarised in the table below. The list of facilities and projects provided in this report is as per information received to date as well as the latest version of the SEZ masterplan.

Table 10: Emissions provided in the Greenhouse Gas Emission Indicator Report

Project	Total indicative planned capacity	Total emissions	Intensity - Calculated from data provided
Coal washery	20 000 000 tpa	No data provided	-
Coke plant	3 000 000 tpa	No data provided	-
Heat recovery power generation	390 MW	No data provided	-
Thermal power plant	3300 MW	19.62 $MtCO_2$/yr	0.85 tCO_2e/MWh
Ferrochrome plant	3000 000 tpa	3.96 $MtCO_2$/yr	1.32 tCO_2e/t
Ferromanganese plant	500 000 tpa	1 $MtCO_2$/yr	1.0 tCO_2e/t
Silicon manganese	500 000 tpa	0.66 $MtCO_2$/yr	1.32 tCO_2e/t
Vanadium-titanium magnetite	10 000 000 tpa	5.28 $MtCO_2$/yr	0.53 tCO_2e/t
High manganese steel	1000 000 tpa	No data provided	-
High vanadium steel plant	1000 000 tpa	No data provided	-
Stainless steel Plant	3000 000 tpa	No data provided	-

Project	Total indicative planned capacity	Total emissions	Intensity - Calculated from data provided
Lime plant	1000 000 tpa	1.25 $MtCO_2/yr$	0.25 tCO_2e/t
Cement plant	2 000 000 tpa	0.51 $MtCO_2/yr$	0.26 tCO_2e/t
Refractories factory	500 000 tpa	No data provided	-
Sewage treatment plant	140 000 m^3/day	No data provided	-
Industrial domestic water plant	300 000 m^3/day	No data provided	-
Light industrial processing zone	No data provided	No data provided	-
Machinery zone	No data provided	No data provided	-
Commercial residential area	No data provided	No data provided	-
Living area	No data provided	No data provided	-
SEZ administration centre	No data provided	No data provided	-
Bonded area	No data provided	No data provided	-
Logistics centre	No data provided	No data provided	-

Areas for which no data was provided are considered to not have material emissions and are therefore not taken into consideration for the rest of this analysis.

The greenhouse gas emissions of the envisioned activities in the SEZ, if the plants are built to have emission intensities as provided in Table 5 above, have been calculated and are shown in Table 11 below. The calculation is based on:

$$\textbf{Emissions } (tCO_2e) = \textbf{Production (tons product) x emission factor } (tCO_2e/\textbf{ton product})$$

The calculation was done for emission factors based on current industry factors, as well as with factors taking decarbonisation for a 2°C target for 2030 into account. Note that the intensities include both scope 1 and scope 2 (energy indirect) emissions. As it is assumed that the electricity produced by the proposed coal fired power station is consumed on the site, reporting of the emissions from the plant would result in double counting in this specific table. The emissions from the coal fired power plant is therefore not reported in Table 11 below.

Table 11: **Annual project emissions**

Plant	Emissions based on 2010 historic intensities	Emissions based on 2°C target intensities for 2030	Difference
Coal Washery	-	-	-
Coke Plant	900 ktCO_2e/y	630 ktCO_2e/y	270 ktCO_2e/y
Heat Recovery power generation	*	*	-
Coal-fired power plant	*	*	-
Ferrochrome plant	13.5 MtCO_2e/y	10.1 MtCO_2e/y	3.4 MtCO_2e/y
Ferromanganese plant	2.2 MtCO_2e/y	1.7 MtCO_2e/y	561 ktCO_2e/y
Silicon-manganese plant	3.5 MtCO_2e/y	2.6 MtCO_2e/y	863 ktCO_2e/y
Carbon Steel Plant	7.2 MtCO_2e/y	4.5 MtCO_2e/y	2.7 MtCO_2e/y
Stainless Steel Plant	3.3 MtCO_2e/y	2.3 MtCO_2e/y	1 MtCO_2e/y
Lime Plant	1.1 MtCO_2e/y	869 ktCO_2e/y	223 ktCO_2e/y
Cement Plant	2 MtCO_2e/y	1.6 MtCO_2e/y	406 ktCO_2e/y
Sewage Treatment Plant	99 tCO_2e/y	69 tCO_2e/y	30 tCO_2e/y
Water Treatment Plant	212 tCO_2e/y	149 tCO_2e/y	64 tCO_2e/y
Total SEZ	**33.7 MtCO_2e/y**	**24.3 MtCO_2e/y**	**9.4 MtCO_2e/y**

**Note*:* *See comment above the table - It was assumed that all electricity consumed by the plants in the industrial complex was produced by the onsite power plant. The Scope 2 emissions included in the calculations therefore relate to the electricity produced at this power plant. The emissions from the power plant are thus excluded to avoid double counting.*

The proposed Musina-Makhado SEZ development is expected to generate approximately **1 billion tonnes of carbon dioxide equivalent of direct and energy indirect emissions** over the lifetime of the project. The largest contributors to these emissions are the ferrochrome, lime and carbon steel plants. A breakdown of these emissions is illustrated in the figure below.

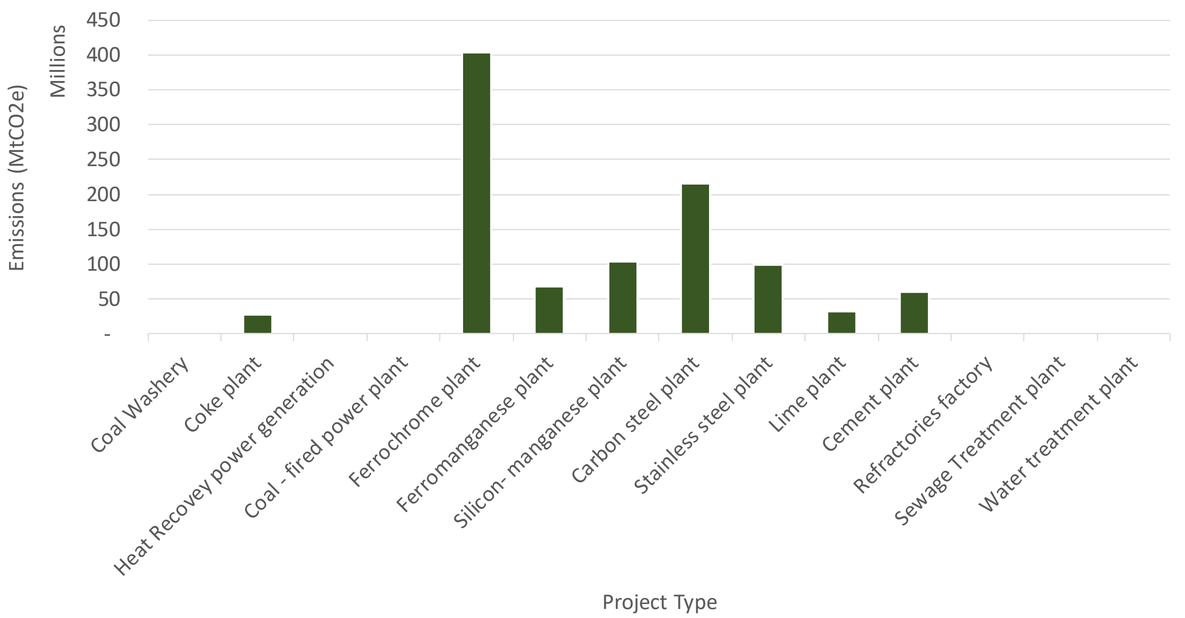

Figure 13: Emissions per project type for the 30 year life of the project

5.2 Impacts on Greenhouse Gas Inventories

The impacts of the Musina-Makhado project's emissions must be considered within the context of both national and international greenhouse gas reduction plans. This will provide for a more holistic understanding of these impacts.

5.2.1 South African Context

Impact ratings of greenhouse gas emissions have been identified to benchmark greenhouse gas inventories, as described in Table 7 above. These ratings apply to emissions that occur with the boundary of South Africa and are as follows:

- **Low:** Emissions up to 10 thousand tCO_2e/yr, or 0.00013% of South Africa's carbon budget
- **Medium:** Emissions up to 1 million tCO_2e/yr, or 0.013% of South Africa's carbon budget
- **High:** Emissions of more than 10 million tCO_2e/yr, or 0.13% of South Africa's carbon budget

In the light of this classification, the Musina-Makhado emissions of more than 10 million tons per year has a **HIGH** impact.

The Musina-Makhado SEZ's calculated emissions inventory in relation to South Africa's remaining portion of the global carbon budget as per Table 7, is presented in Table 12 blow:

Table 12: The Musina-Makhado SEZ development's emissions relative to South Africa's carbon budget

Emissions	
South Africa's carbon budget	7,512 Mt CO_2e
Scope 1 and 2 emissions of the project activities using 2020 intensities over the life of the project	1,010 $MtCO_2e$ - equivalent to 13% of SA's carbon budget
Scope 1 and 2 emissions of the project emissions using 2°C target intensities for 2030 over the life of the project	728 $MtCO_2e$ - equivalent to 10% of SA's carbon budget

The impact of the Musina-Makhado project's greenhouse gas inventory is considered to be **HIGH** due to the total emissions from the project being between 11% and 16% of South Africa's carbon budget.

This impact assessment should also be considered in the context of the local policy environment. South Africa submitted their Nationally Determined Contribution (NDC) in response to the Paris Agreement in 2015 and outlines the national emissions trajectory up to 2050. South Africa's national emissions are expected to peak between 2020 and 2025, plateau for approximately a decade and decline thereafter in absolute terms. The Musina-Makhado project will add an additional 10% onto the emissions in the NDC, thereby significantly altering the national greenhouse gas trajectory that has been published and committed to.

The IRP Draft Update 2018 makes allowance for two additional coal power stations to be commissioned. These stations are already in the planning stages. The power plant planned as part of the Musina-Makhado SEZ development would therefore require a Ministerial Determination before construction can begin. The update to the IRP aims to reduce the emissions of South Africa's electricity generation sector by reducing the use of emission intensive technologies such as coal power stations. The addition of the power plant at Musina-Makhado would counter the objective of South Africa to reduce its emissions as a result of coal fired power generation.

The effect of adding the Musina-Makhado SEZ power plant can be seen in the graph below which plots the emission intensity of the national grid as per the IRP Draft Update 2018.

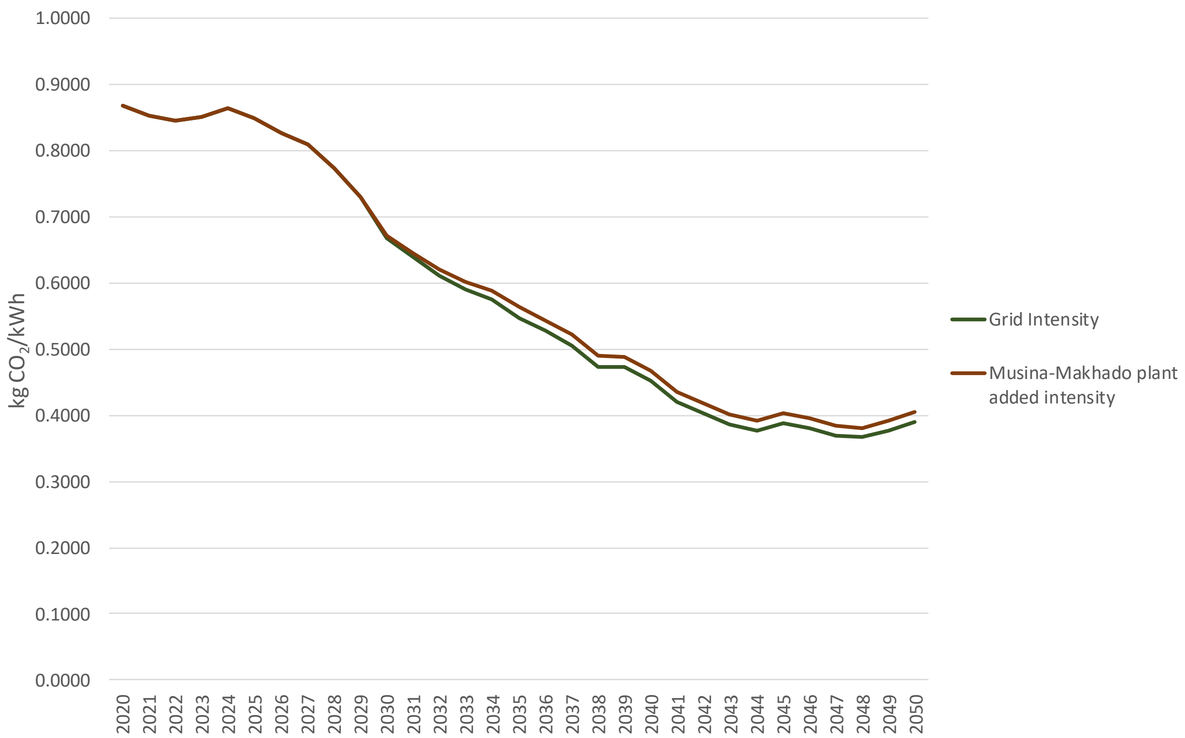

Figure 14: Effect of the project on the IRP

5.2.2 Global Context

Climate change is a global phenomenon making it difficult to distinguish between local and international climate change drivers. Global anthropogenic climate change is caused by the accumulation of greenhouse gas emissions.

The impacts of the Musina Makhado project will impact the global inventory particularly as the planned activities in the project are in emission intensive industries. This analysis is based on the assumption that the construction of the plants considered in this project will not increase the global demand for the metals to be produced. The increased demand will be driven by the growth of the new green economy, as shown in Figure 15 below. It is therefore assumed that production from the planned project would crowd out production from old plant with lower efficiencies, higher cost, and higher emissions.

The World Bank conducted a study which revealed that increased commodities, particularly metals, will be necessary to achieve the various development objectives required by the Paris Agreement targets[32]. The increased demand for steel in three different emission reduction scenarios can be seen in the following figure.

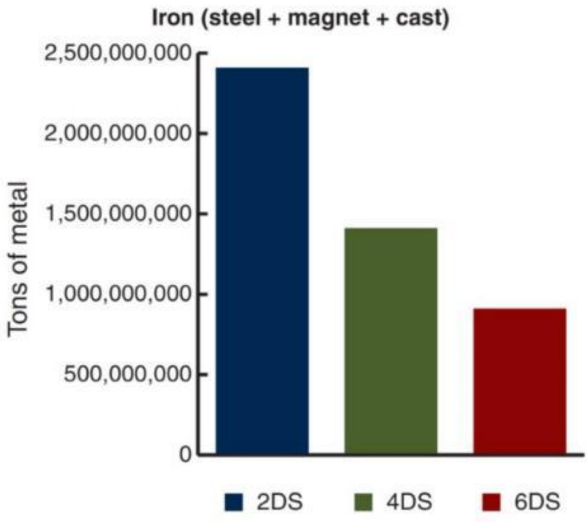

Figure 15: The growing role of steel for a low carbon future (2DS - 2˚C scenario. 4DS - 4˚C scenario, 6DS - 6˚C scenario).

Steel and other metallurgical plants generally have long life-spans. In this context, one of the biggest challenges in the decarbonisation of the world economy lies in the handling of the older, high emission plants. The construction of modern, low emission, plants is imperative if the world is to meet its emission reduction targets. In this context the construction of the SEZ could contribute to the decarbonisation of the global economy by introducing low emission plants. The difference between the emission intensities associated with the current fleet of metallurgical plant in the world, and the recommended intensities as per this report, for the volumes of production planned for this project, is shown in the last column of Table 11 above.

If the plants in the SEZ are built to the intensities as indicated in Table 11 above, it could reduce global greenhouse gas emissions by around 10 million tons per year.

5.3 Impacts on Climate Change

The high-level impacts from the perspective of the national and international greenhouse gas inventories do not necessarily reflect the impacts of the Musina-Makhado project from the domestic or global environmental perspective.

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32 World Bank, 2017. *The Growing Role of Minerals and Metals for a Low Carbon Future,* s.l.: World Bank.

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 greenhouse gas emissions from the project to specific effects on climate change.

The impacts of the Musina-Makhado project's greenhouse gas emissions have been assessed in Table 13, as per the Environmental Impact Criteria detailed in Section 4.1.2 of this report. The assessment results indicate that the activities undertaken in the project will produce greenhouse gas emissions that will contribute to the national and global inventories and climate change.

Table 13: Climate change impacts of the Musina-Makhado SEZ Development emissions during operations

Nature: The greenhouse gas emissions produced as a result of the industrial 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 greenhouse gas emissions of any individual source, such as the proposed Musina-Makhado SEZ Development. The total Scope 1 and 2 emissions from the operational phase of the SEZ are calculated to be 727 million tCO_2e[33], which is 10% of the South African carbon budget of 7,572 $MtCO_2e$. The total emissions from the industrial complex's operation are therefore above the 0.13% 'high' rating threshold in relation to the national carbon budget, as set out in Table 7.

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?	To a limited extent	To a limited extent

Mitigation: It is proposed that the environmental authorisations for the individual plants in the SEZ specify that the maximum emission intensities for the plants to be built is as would be required by the science based target trajectories for 2030. This recommendation is based on the required decarbonisation rate for the global economy as well as the assumption that the new plants will not be retrofitted during the first 10 years of operation.

Cumulative impacts: The emissions from the operational phase of the mine are cumulative. The increase of greenhouse gasses in the atmosphere lead to an increase in global temperatures and resultant climatic changes.

[33] Using 2°C target intensities for 2030.

Residual risks: Greenhouse gasses 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 SEZ emissions, will remain even after the various activities within the SEZ have been decommissioned.

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

There are options to mitigate the greenhouse gas emissions of the SEZ during the operational phase of the various activities. These options will not alter the impact of greenhouse gas 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 greenhouse gas emissions.

5.4 Project Alternatives

To date detailed designs with regards to the various activity processes envisioned for the SEZ have not been available. A Greenhouse Gas Emission Indicators Report was provided by the Client, however no indication of methodology, variables and input data were provided to unpack the emission intensities for a full comparison. In addition, the lack of design data and process details prevent an analysis of possible alternatives. This assessment therefore urges that the EIAs for the various activities within the SEZ consider appropriate alternatives in terms of project design to identify opportunities for potential mitigation alternatives related to emission intensities.

As discussed, this report has suggested emission intensities in terms of a 2030 timeframe and best practice. Table 14 below provides a comparison between the 2010 benchmark intensities, proposed 2030 intensities as well as the emission intensities provided by the Client. The following must be noted:

- The intensities for the Ferrochrome and Ferromanganese plants were adjusted using an energy intensity of 3.5MWh/tonne product[34] and the South African grid emission factor of 0.911tCO_2e/MWh. This allows the intensities to be accurately compared. The intensities for the silicon-manganese plant cannot be compared as the boundaries are unknown. The difference between the proposed 2°C target intensity for 2030 and the provided information warrants a review of the figure contained in the Greenhouse Gas Emission Indicators Report as provided by the Client.
- The intensity for the cement plant was calculated based on the provided information. In comparison with the benchmark intensity, the intensity from the Greenhouse Gas Emission Indicator Report is much lower. It is therefore recommended that final EIA of the plant relook at this intensity.

34 Based on consultation with an international ferro alloys expert

Table 14: Emission intensity comparison

Plant	2010 Intensity	2°C target intensity for 2030	Intensity provided in Greenhouse Gas Emission Indicator Report
Coal Washery	-	-	-
Coke plant	0.30	0.21	-
Heat Recovery power generation*	-	-	-
Coal - fired power plant*	-	-	-
Ferrochrome plant	4.49	3.37	4.51
Ferromanganese plant	4.49	3.37	4.19
Silicon- manganese plant	6.90	5.18	1.32
Carbon steel plant	0.60	0.37	-
Stainless steel plant	1.11		-
Lime plant	1.09	0.87	1.00
Cement plant	1.00	0.80	0.26
Sewage Treatment plant	0.0007	0.0005	-
Water treatment plant	0.0007	0.0005	-

Note: *It was assumed that all electricity consumed by the plants in the industrial complex was produced by the onsite power plant. The Scope 2 emissions included in the calculations therefore relate to the electricity produced at this power plant. The emissions from the power plant are thus excluded to avoid double counting.*

The above table indicates that the emissions intensities, as provided, related to the Ferrochrome, Ferromanganese and Lime plants are above the suggested 2030 emission intensities. Therefore, these plants should consider mitigation actions as part of their current design processes to reduce their respective emission intensities in line with both local and global climate commitments.

In terms of mitigating the impact of the emission intensities, as listed in Table 11 above, the following should be considered in the detail design of the various plants:

- The production of ferrochrome, ferromanganese and steel results in off gas due to the processes used[35]. This off gas can be used in gas engines for power generation. This would result in less electricity sourced from a carbon emission intensive source such as a coal fired power plant.
- Slag is a waste/by-product of the metal smelting process. This slag is often granulated using a water jet; a process which uses large volumes of water. This process also does not allow for the recovery of the heat generated. The cooling of one tonne of slag can release approximately 1.8GJ of heat. An alternative process can be used which is termed dry slag granulation[36].

35 G. Ramakrishna et al, *"Exergy and its Efficiency Calculations in Ferrochrome Production"*, 2014, The Minerals, Metals &Materials Society and ASM International

36 CSIRO, "*Dry slag granulation: producing valuable by-products from waste",* 2 January 2019, Australia

- In dry slag granulation, the molten slag is subjected to centrifugal forces using a spinning disc which causes the slag to atomise. The slag is then quenched and solidified using air to recover the waste heat. This produces a product that can be used for cement manufacturing in addition to the recovered heat. The recovered heat can be used for several purposes including preheating and steam generation. This avoids emissions in two areas: those associated with clinker production for cement manufacture and the emissions from power generation if the heat is used to produce steam for a steam turbine.
- Coke oven gas is produced during the manufacturing of coke. This gas has various uses which can contribute to reducing emissions and increasing efficiency. These include preheating the coke oven with the gas and using the coke oven gas for power generation. The gas can also be used in a blast furnace as a supplementary fuel.
- Biomass can be used for power generation and is a less carbon intensive source than coal. This could be considered as an alternative for power generation in the Musina-Makhado SEZ making use of alien invasive vegetation in the area. Further investigation would be required into the feasibility of this as it takes approximately 1 tonne of biomass per hour to generate 1MWh of electricity.
- Waste heat recovery can be implemented in the lime plant which can then be used for several other uses. These include using the heat for drying limestone and preheating in other plants. The heat can also be used for electricity generation which can then be used where required in the industrial complex to offset the electricity required of the emission intensive coal power plant.

6 Impacts of Climate Change on the Project

Due to the interdisciplinary and cross cutting nature of climate change, climate vulnerability is not only caused by the level of exposure, but also by 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.

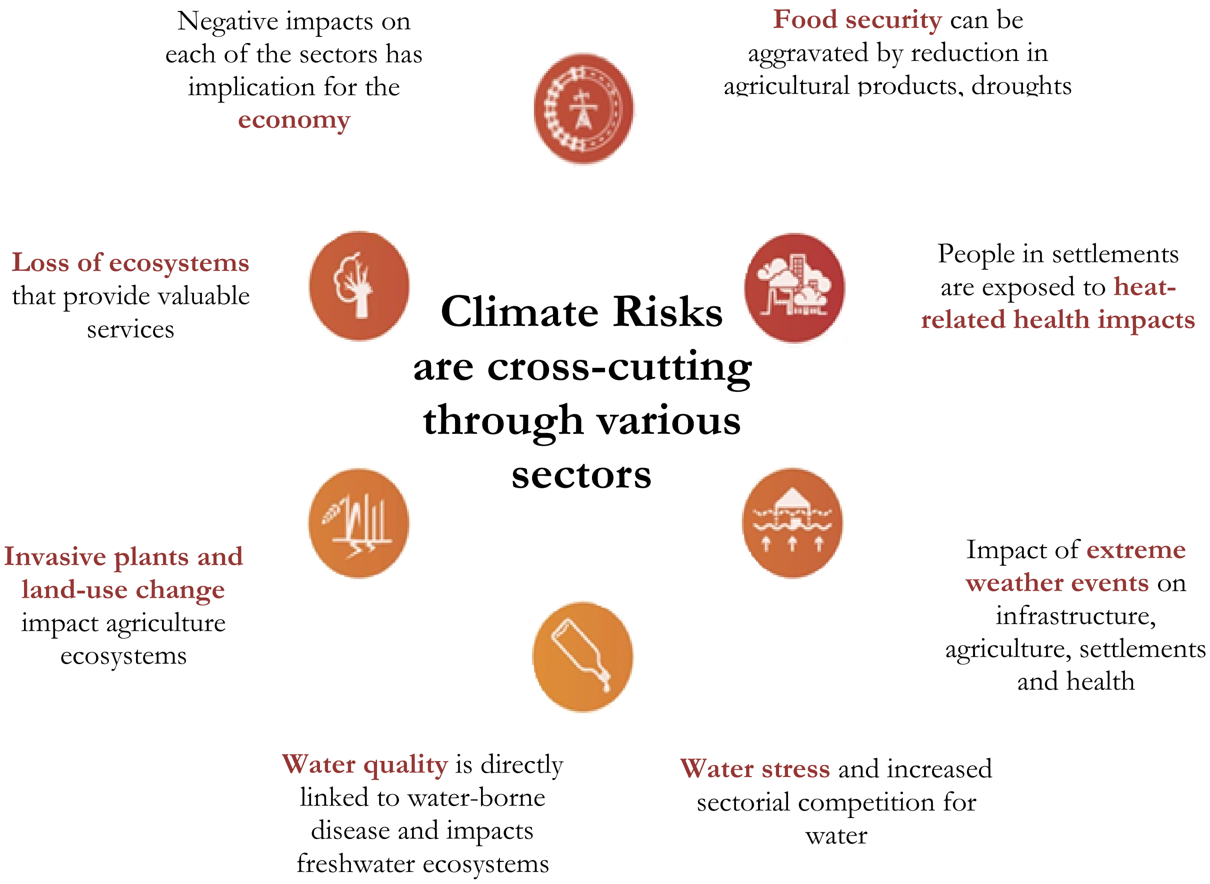

Figure 16: Climate risks impacting various sectors (adopted)[37]

South Africa is already experiencing detrimental climate change impacts. These include, for example, prolonged regional droughts and flash floods. Such events result in water constraints and operational stoppages in production and industrial processes. However, the most significant effects of climate change are likely to emerge over the medium to long term. The timing and magnitude of these effects are uncertain. To account adequately for the potential climate change effects in planning processes, companies need to consider how climate related risks and opportunities, as well as the associated impacts, may evolve under different conditions.

The Vhembe District Municipality has acknowledged that climate change poses a threat to the development of the region, the environment and its residents. The proposed SEZ faces a number of these 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.

Core operations for this assessment include the plants within the boundary of the proposed SEZ, as indicated in Table 1 in section 2.2. The core operations are expected to be exposed to both

[37] 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.

physical and transitional risks as a consequence of climate change. The value chain of the proposed SEZ is diverse and include a number of inputs such as water, diesel, coal, iron ore, and lime.

For the purposes of this assessment, water will be assessed in more detail within the value chain under section 6.2 as it influences the majority the SEZ as a whole. Water is a key input for many of the industries within the SEZ and is significantly impacted by climate change. It is expected that the value chain will also be exposed to both physical and transitional risks as a consequence of climate change. Below outlines a climate change resilience assessment identifying the impacts climate change may have on the project.

6.1 Emission scenarios and impact analysis

Emissions scenarios for this report are described by using Representative Concentration Pathways (RCPs) which are scenarios that include time series of emissions and concentrations of greenhouse gases, 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[38]. Four RCP's are used in the Fifth IPCC Assessment[26] 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 very 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.

The two emissions scenarios considered in this assessment are:

- 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.
- 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 give 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 which aim to effect limited change within one area of national life over a timeframe such as South Africa.

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

It is important to note that different components related the SEZ (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 the following figure.

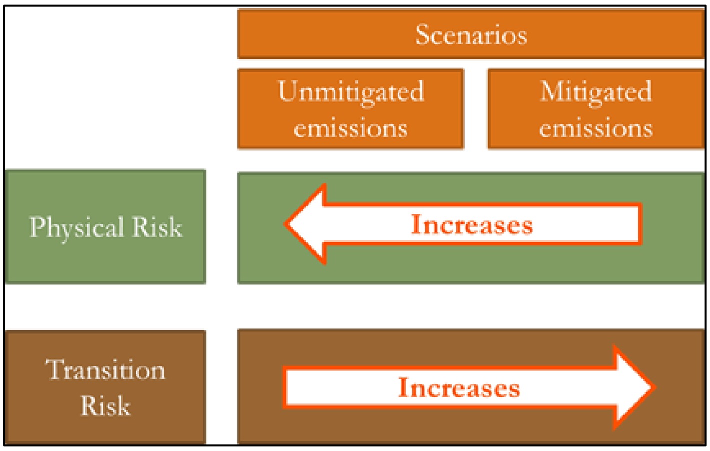

Figure 17: Forward looking scenario analyses[39]

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 impacts of climate change are discussed further in relation to SEZ core operations, value chain and broader network below by considering temperature, water, social, biodiversity and transitional risk aspects.

6.2 Increased Temperature

Climate change models predict that temperatures are to increase in the Limpopo province by as much as 2°C by 2035, by 1-2°C between 2040 and 2060 (or between 2-5°C in the high-end scenarios, RCP 8.5), and by 3-6°C between 2080 and 2100 (or 4-7°C in the high-end scenarios, RCP 8.5)[12]. Rising temperatures would also result in an increase in the intensity and frequency of heat waves and wind speed. The culmination of these stresses can result in a greater number of people at risk of heat-related medical conditions as is discussed below.

[39] Promethium Carbon

The Vhembe District Municipality has identified increases in temperature and the frequency of extreme weather evens as a developmental challenge within the Integrated Development Plan[12]. They have further indicated that climate change may make conditions more favourable for the incubation and transmission of waterborne diseases and disease carrying vectors. This could impact business continuity of the SEZ as a result of labourers falling ill and being unable to work.

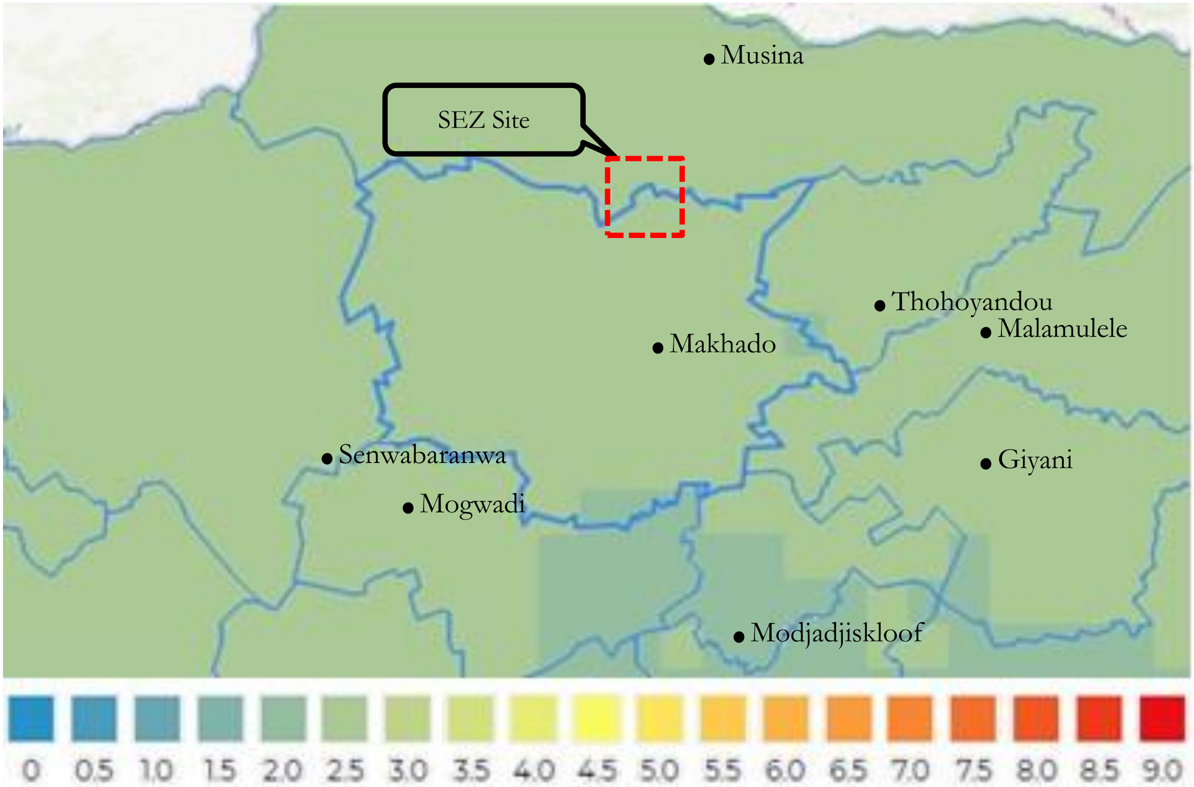

Figure 18: Projected average temperate change for the period 2021 -2050, relative to the baseline period (1961 – 1990)[27].

From an operational perspective, heat stress directly impacts on labour productivity and is a major occupational health risk. High heat exposure restricts worker'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[40].

Increasing numbers of hot days, especially for people undertaking manual labour outdoors, will pose profound threats to the core operations of the SEZ in terms of occupational health and labour productivity. The can result in a loss of labour capacity which has further indirect impacts

[40] 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

on the livelihoods of these individuals, their families and the communities as a whole, particularly those of which rely on subsistence farming[41].

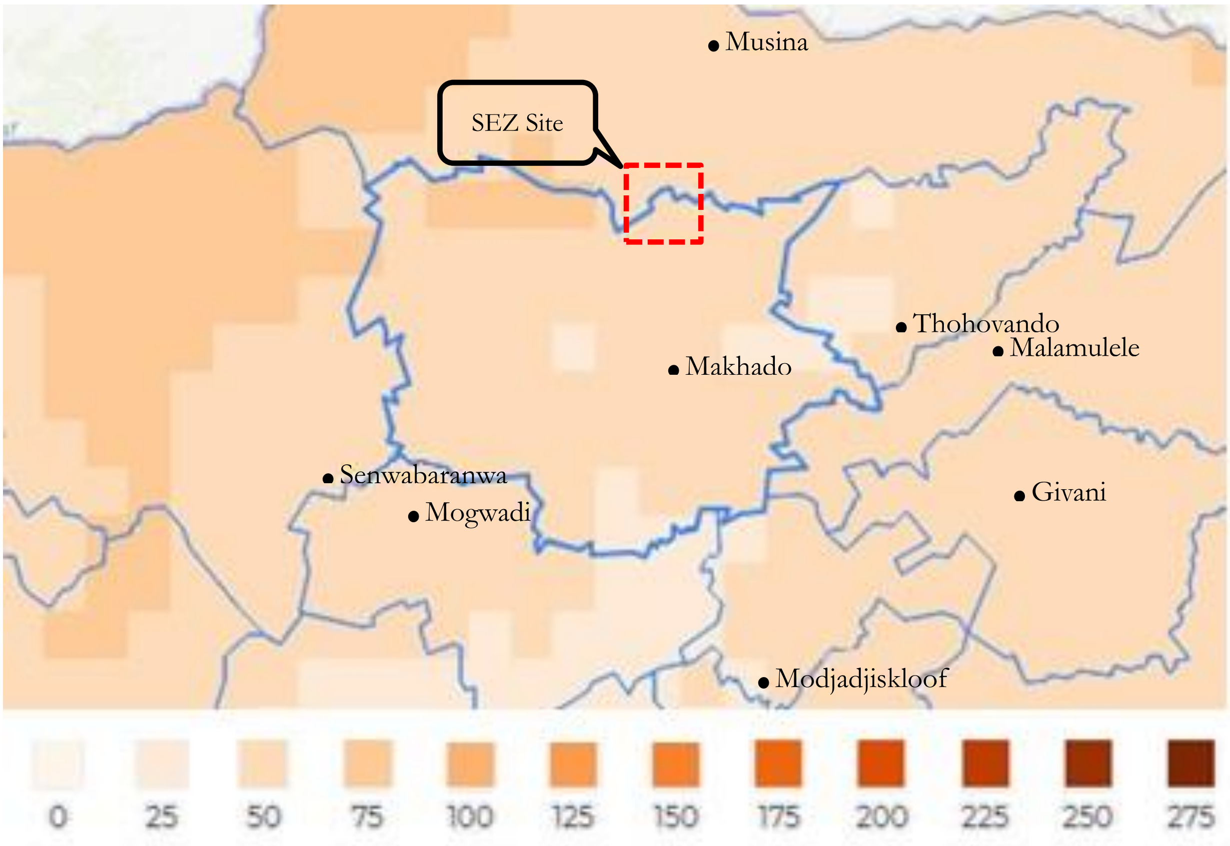

Figure 19: Projected change in the number of very hot days (>35˚C) for the period 2021 - 2050, relative to the baseline period (1961 – 1990)[27].

With regards to Vhembe District area, labour productivity is projected to decline significantly under a high emissions scenario. The figure below indicates the projected number of very hot days to increase to between 17 and 57 days under the worst case scenario RCP 8.5.

Prolonged hot periods and increased temperatures may also reduce the operating efficiency of machinery or heavy goods vehicles. Equipment operating thresholds may be exceeded during episodes of extremely high temperatures. High temperatures could lead to extended use of air conditioners and ventilation systems within trucks and facilities operations. This will increase diesel consumption in the vehicles and electricity consumption in buildings.

[41] 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.

6.3 Water related impacts

Water security and groundwater are considered as part of this specialist climate change impact assessment. This is due to the fact that water is a key resource that will be affected as a result of climate change. In the case of the proposed SEZ, water is considered from a regional and international perspective as water is envisaged to be sourced from Zimbabwe.

6.3.1 Water internationally

The projected water use for the SEZ is estimated at 80 million m^3/annum. This demand will create immense pressure on the local and cross-border water resources as well as the regional transferring catchments relevant to this study area. As indicated in section 2.3.3 a large portion of water is planned to be supplied by Zimbabwe. Table 15 below indicates the potential water resources within Zimbabwe considered to supply the SEZ.

Time period	Source Catchment	Details
Short term	Mzingwane	**Beitbridge - Musina Integrated Water Supply Scheme** - Potable water from Beitbridge water treatment plant - Raw water from Zhove via gravity for pick up at Beitbridge
Medium term	Runde	**Tugwi- Mukosi Dam** – A newly completed dam located 250 km from Beitbridge was identified as a potential project with surplus water that could be diverted to South Africa
Long term	Mzingwane	**Thuli – Moswa Dam** About 420 million m^3 capacity dam upstream of Zhove
	Save	**Kondo – Chitowe Dam** – The project will yield more than 820,000 ML. This dam site has a potential to sustain both Zimbabwean and South African water demand

Table 15: Potential source of water in Zimbabwe[10]

Surface water in Zimbabwe accounts for 90% of the country's supply[42]. Conversely there is very limited knowledge on how much ground water there is and the potential to utilise this water for the country's needs. Nevertheless, the impacts of climate change in these catchment areas will impact both surface and ground water which will affect Zimbabwe as well as the SEZ which envisages to use water from Zimbabwe for day to day operations.

In order to understand the impact on Zimbabwe's water resources, the CSIRO Mk3 global circulation model (GCM) was used. The model indicates that under worst case and best case emissions scenarios, average annual precipitation will decrease in all of the Zimbabwean catchments except for Mazowe and Manyame which are predicted to remain relativity the same[43].

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42 D, Brown *et al*, 2012. *Climate change impacts, vulnerability and adaptation in Zimbabwe*, IIED Climate Change Working Paper. 4, December 2012.Viewed 26 July 2019 https://pubs.iied.org/pdfs/10034IIED.pdf

43 R, Davis and R, Hirji 2014. *Climate change and water resource planning, development and management in Zimbabwe*, An issues paper, World Bank. Viewed 26 July 2019

Runde and Mzingwane water catchment areas, which are sources of short and medium term water for the SEZ, will be affected the most. It is predicted the mean annual precipitation will decline in the region of between 12% for higher mitigation emission scenarios and 16% for lower emission mitigation scenarios by 2050. This significant uncertainty related to water supply poses a major risk to the SEZ.

Climate change will also negatively impact the groundwater recharge rate for the areas and water supply for various water catchments. For limited or business as usual emission mitigation scenarios, precipitation would continue to decline for almost all catchment areas. On the other hand, for high emissions mitigation scenarios, affected water catchments such as Gwayi, Mzingwane, Runde, Sanyati and Save, could stabilise in terms of precipitation or start to recover between 2050 and 2080.

An additional concern to the water resources of Zimbabwe is climate induced temperature increase. With Zimbabwe being heavily reliant on surface water for the country's water needs, increasing temperatures will accelerate the rate of evaporation and impact surface water qualities in dams and rivers. In 2007, many dams were decommissioned due to evaporation of water resulting in dams running dry. With increasing temperatures predicted through to 2100 (Figure 7) evaporation has been estimated to intensify by between 4-25% on the river basins of Zimbabwe. This coupled with rainfall variability heightens water security risks and water supply risks to the SEZ.

The implication of climate change on these catchments need to be considered in detail in terms of potential operational impacts on the SEZ and the water demand for both the Musina a Makhado Municipalities. Furthermore, water demand of the SEZ and the impact of climate change on above mentioned Zimbabwean catchments need to considered on the people living in Zimbabwe who are dependent on this water for their livelihoods.

This is particularly relevant as Zimbabwe is extremely vulnerable to the impacts of the climate change due to the fact that 62% of the total population reside in rural areas and are heavily dependent on climate sensitive water resources[44]. A report by the Southern African Development Community further supports this notion in which it found that the population of Zimbabwe is at very high risk of groundwater drought which could rise from 32% to 80% by 2100. Placing additional strain on the limited water sources, within the context of existing socio-economic vulnerabilities should be carefully considered and evaluated.

6.3.2 Water locally

The proposed SEZ falls within the Sand and Nzhelele catchment areas within the Limpopo Province. The Sand River catchment is the driest catchment area within Vhembe District Municipality. Surface water resources in the catchment area are limited to the small Seshego and

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http://documents.worldbank.org/curated/en/925611468329355687/pdf/937310WP0Box380babwe000Issues0Paper.pdf

44 Chagutah, T., 2010. *Climate Change Vulnerability and Preparedness in Southern Africa*: Zimbabwe Country Report. Heinrich Boell Stiftung, Cape Town.

Houtrivier dams and run-of-river abstractions. Groundwater is the only dependable water source for many rural settlements and villages with urban requirements being augmented from transfers from neighbouring Water Management Areas (WMAs).

Table 16 indicates the Limpopo development level catchment water balances with no interventions. The Sand catchment indicates a negative water balance of -4.7 million m^3/annum while the Nzhelele indicates a positive balance of 8.7 million m^3/annum. The current surface water demand per capita for Makhado is 87.49 litres per person per day (l/p/d) with a supply of 91.83 l/p/d. Musina indicates a higher demand of 148.71 l/p/d and a supply of 283.21 l/p/d, illustrating that Musina is more dependent on surface water than Makhado[45]. An addition 80 million m^3/annum will place major stress on the area's available water resources. This additional water burden should also consider the potential urban expansion that would follow the development of the SEZ, placing further strain on the area's water capacity.

Table 16: Limpopo development level catchment water balances, 2010[46]

Catchment	Water requirement (million m^3/yr)*	Water availability (million m^3/yr)	Water balance (million m^3/yr)
Matlabas	7	7	0
Mokolo	61.6	61.2	-0.4
Lephalale	75.1	77.3	2.3
Mogalakwena	156.8	152.3	-4.5
Sand	292.6	287.8	-4.7
Nzhelele	39.4	48.1	8.7
Total	632.5	633.7	1.4

** Excludes IAPs and commercial forestry (streamflow reducers)*

The Vhembe District Municipality is currently experiencing issues of water scarcity and quality as all catchments in Limpopo excluding the Matlabas catchment indicate water quality issues that are expected to deteriorate over time. Climate change is expected to further exacerbate these problems as a result of increasing drought events.

Under no mitigation scenario RCP 8.5, drought is projected to increase in the Musina and Makhado areas for the period 2035 – 2064. Increased drought would impact availability of water for the SEZ operations which is particularly of concern for the thermal plant and ferrochromium plant which require large amounts of water to operate. It is anticipated that SEZ will acquire energy from the thermal power plant, therefore, should the plant not be able to operate due to water constraints this will impact the entire SEZ's productivity.

45 Le Roux, A., van Niekerk, W., Arnold, K., Pieterse, A., Ludick, C., Forsyth, G., Le Maitre, D., Lötter, D., du Plessis, P. & Mans, G. 2019. *Green Book Risk Profile Tool. Pretoria*: CSIR. Available at: https://riskprofiles.greenbook.co.za/

46 Draft Reconciliation Strategy Report, 2016. Department of Water and Sanitation, Republic of South Africa P WMA 01/00/00/02914/11A. Viewed 10 June 2019 http://www6.dwa.gov.za/Limpopo/Documents/2016/Preliminary%20Reconciliation%20Strategy%20Report%20Draft%2020160920.pdf

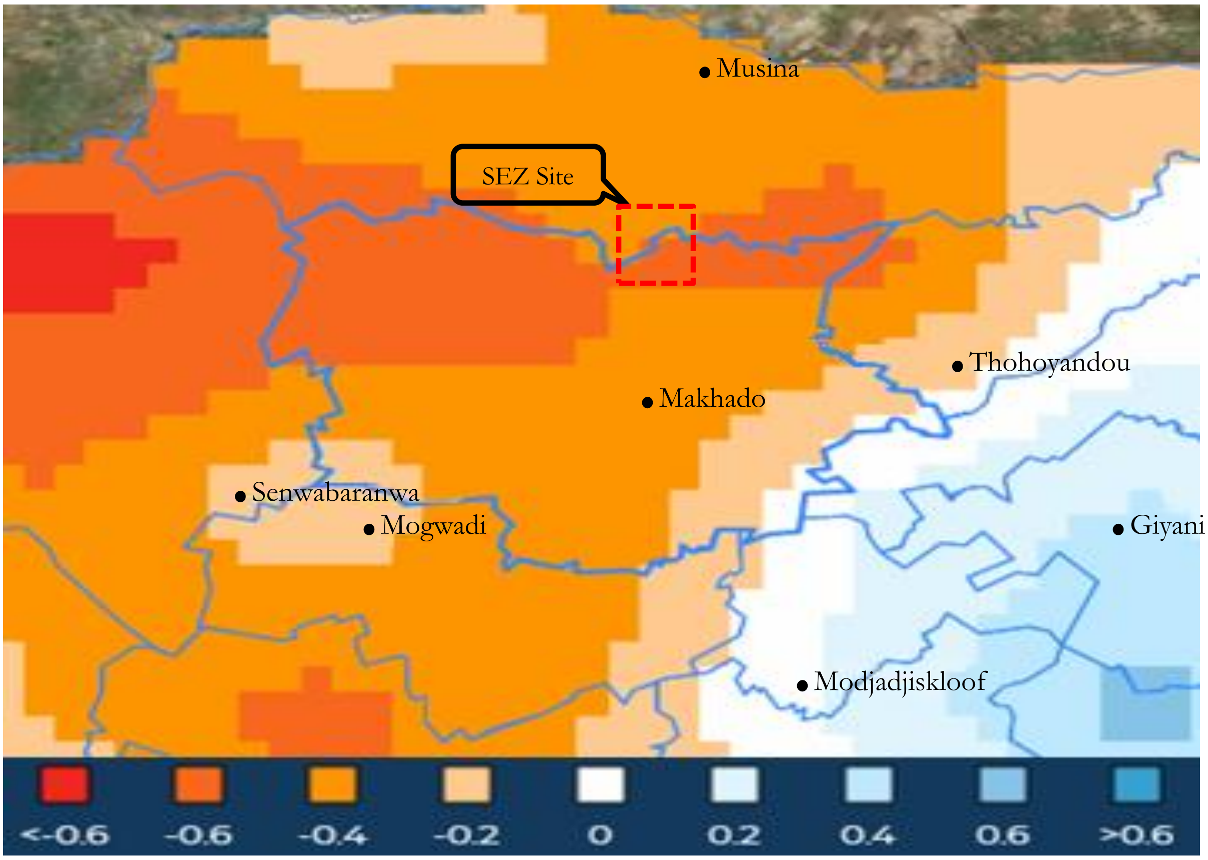

Figure 20: Projected change in drought tendencies for the period 2035 - 2064, relative to the baseline period (1986 – 2005) under the low mitigation scenario RCP 8,5[27].

A negative value is indicative of an increase in drought tendencies per 10 years

Almost all of the provincial water resources have been fully developed and are allocated. Forty three per cent of the dams in the province have safety issues with additional issues of high water contamination impacting the quality of the water. With the SEZ predicted to be a large consumer of water, water availability and quality for other downstream uses become concerning, particularly in drought situations. The majority of the provincial water use demand is used for irrigation, mining and energy and some water to service rural areas[12]:

Limpopo depends mostly on surface water sources, however, a large number of rural households depend on groundwater for domestic use. In 2011, 52,3% of Limpopo's population had access to piped water within their property, with almost a quarter of a million people not having access to formal water infrastructure. The following climate related risks have been projected for the Limpopo river basin[12]:

- Decreased availability of water in rivers
- Changes in the timing of high and low flows
- A higher incidence of floods
- Increased risk of water pollution and decreased water quality

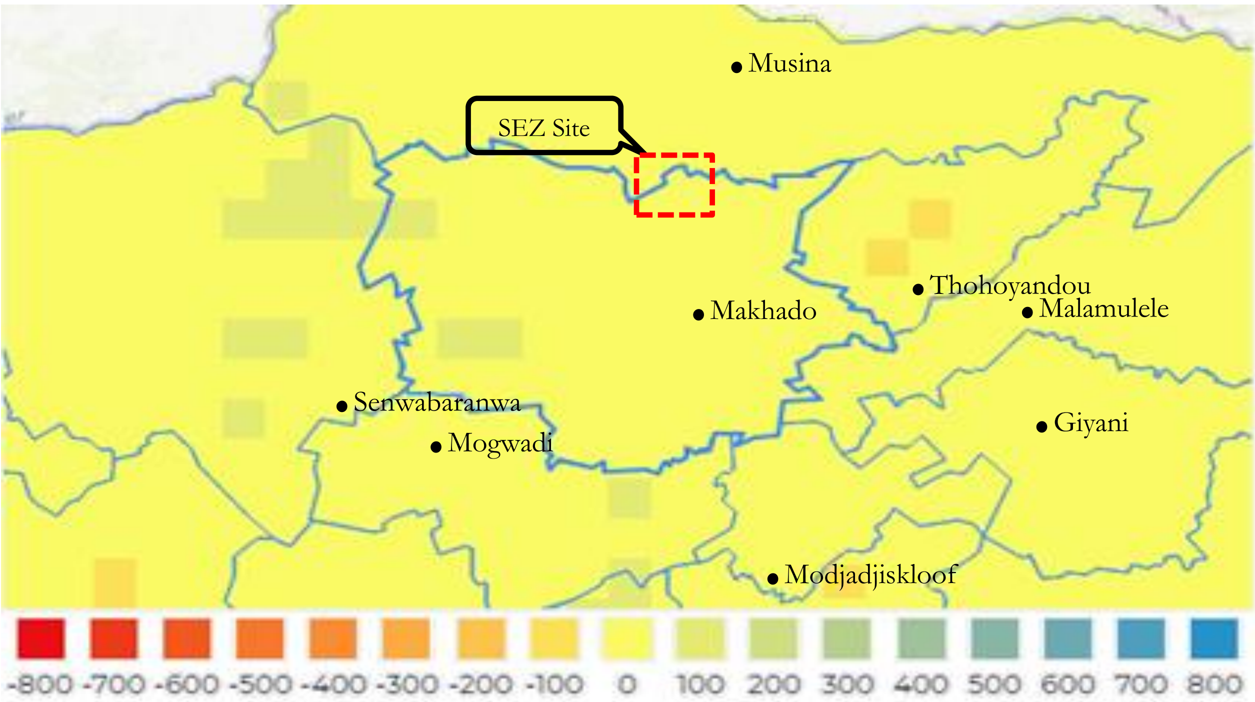

Figure 21: Projected change in average rainfall for the period 2021 -2050, relative to the baseline period (1961 – 1990)[27].

A key challenge related to climate change, and specifically its impact on precipitation patterns, is the variability it could cause. In Limpopo there are indications that, in addition to prolonged periods of drought, the Province could also experience greater variability in rainfall (Figure 21) and extreme rainfall days (Figure 22). These intense rainfall days could result in flash flooding, which could cause both infrastructural, operational and labour safety damages.

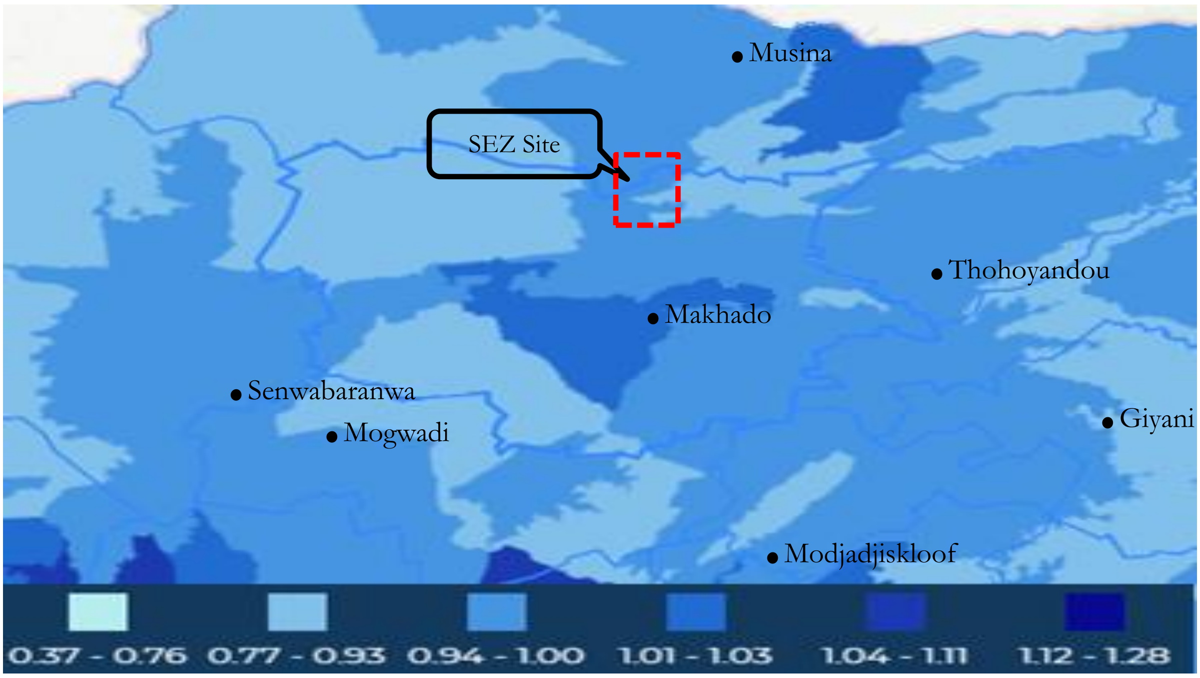

Figure 22: Projected change in extreme rainfall days under RCP 8.5 for the year 2050[27].
A value of more than 1 indicates an increase in extreme daily rainfalls

In addition to the above, the water stress specifically related to climate change, for the proposed SEZ, was assessed using the World Resources Institute's (WRI) Aqueduct tool[47]. Projected changes in water availability or impacts on water resources show how development and/or climate change are expected to affect water stress in a particular area. Water stress is the ratio of total withdrawals to total renewable supply in a given area. The WRI Aqueduct tool uses twelve different risk categories including physical, regulatory and reputational risks to determine water risk. Reference is also made to the baseline status and overall water risk of a particular area. The WRI Aqueduct indicates that the overall water risk of the area in which the proposed SEZ is situated, is "*Medium Risk*".

[47] World Resources Institute, n.d. *World Resources Institute Aqueduct: Measuring and Mapping Water Risk,* viewed 6 June 2019: http://www.wri.org/our-work/project/aqueduct

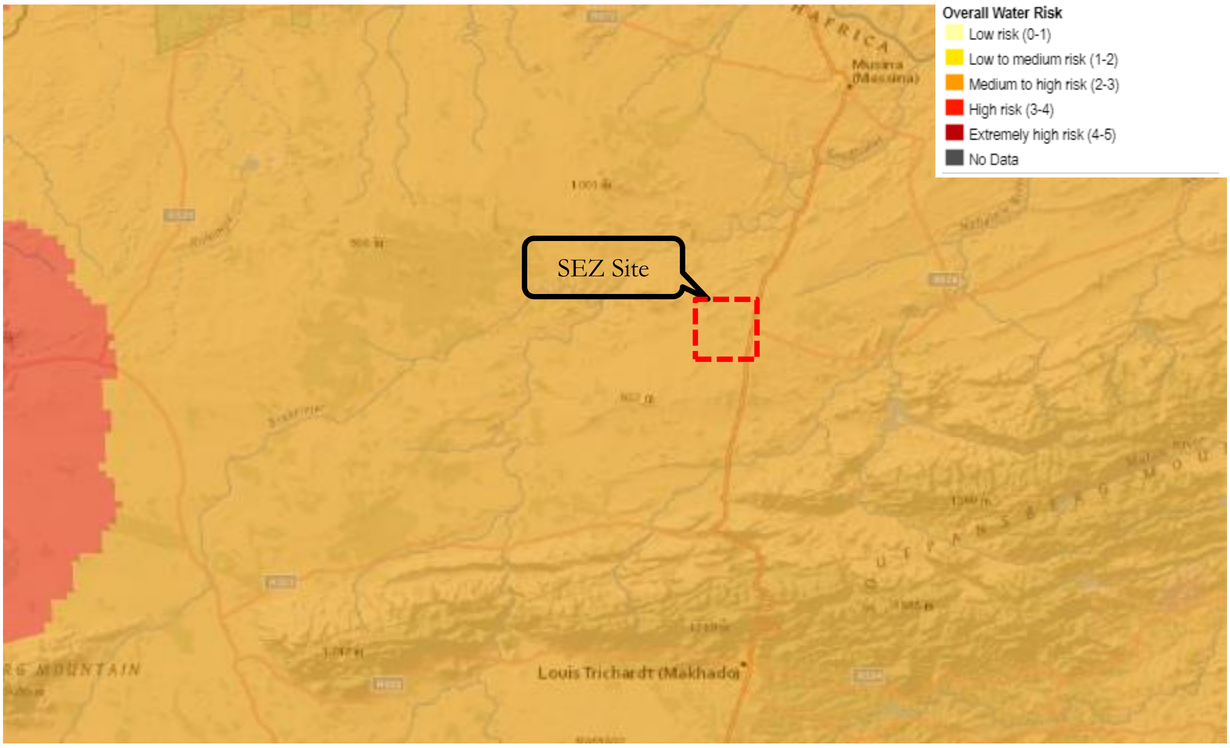

Figure 23: SEZ - overall water stress[47].

The overall "*Medium Risk*" rating indicates, as per earlier comments in this section, the possibility of process disruptions and the reduced availability of water which could interrupt the operation of the metallurgical plants in the SEZ. Therefore, water scarcity issues pose a critical concern from an operational point of view. In addition to the overall water risk, water storage was assessed for the purposes of this study.

Water storage relates to the water storage capacity upstream of the proposed SEZ relative to the water supply to the facility. In terms of the proposed SEZ, water storage is classified as "*Medium to Low*", which means that the availability of buffer capacity to withstand variation in water supply is at risk in the area. Furthermore, surrounding areas to the west of the proposed SEZ indicate as having "*Low*" to *"extremely low"* capacity for buffering in case of variations of water supply including for droughts or floods.

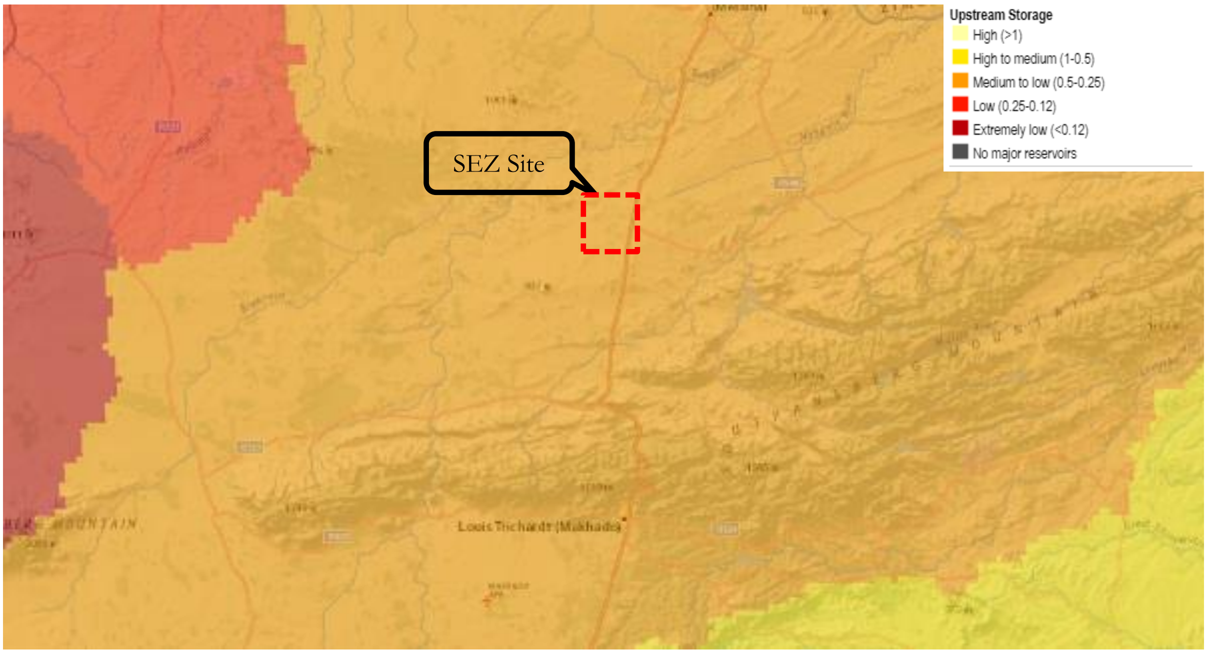

Figure 24: SEZ - upstream storage[47].

Under existing water constrained considerations and due to a low buffering capacity of the area, water stress could lead to social and environmental pressures on the proposed SEZ. Furthermore, increased competition for water within the District and across municipal areas could increase water pressure on the proposed facilities and can therefore have impacts on the operation. The SEZ will increase pressure on water availability for the surrounding municipalities due to the large demand from the SEZ. It is therefore crucial that the water balances for the SEZ and the surrounding area are determined for current and future use and importantly, the impacts of climate change on this demand be considered.

An additional key climate risk associated with water in the area pertains to inter-annual variability. Figure 25 below indicates that the SEZ falls within an area with a high risk in terms of water supply year on year. This carries with it significant consequences for the area as well as the SEZ as water supply will fluctuate. Furthermore, climate change is expected to exasperate these issues through various extreme weather evens such as drought and high frequency rainfall periods.

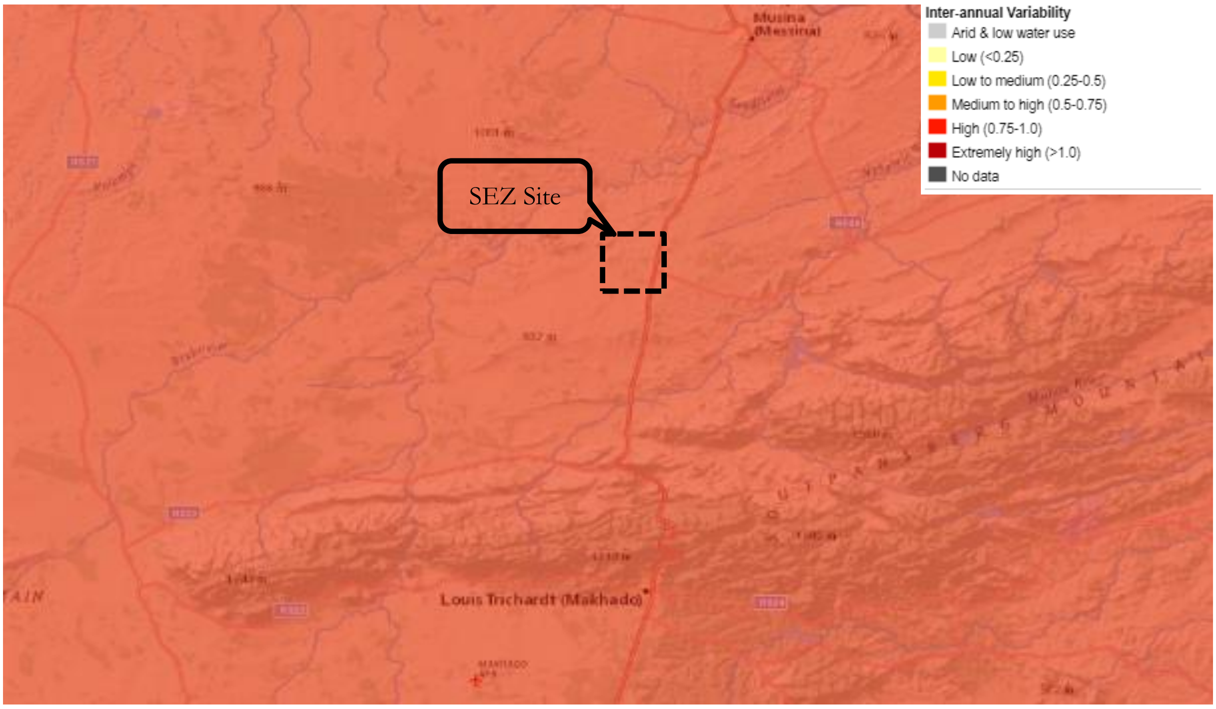

Figure 25: SEZ - inter annual variability[47].

This again highlights the importance of a thorough water balance for the area which is cognisant of all these climate change water risks, now and in the future. Further consideration should be given to worst case scenarios and water alternatives in the episode of extreme weather events. This is to ensure that one caters for water risks at a regional scale and that the impacts of climate change are buffered and limited. It is therefore critical that the Environmental Impact Assessment, to be undertaken for each of the individual plants to form part of the SEZ, must prepare a water balance which takes cognisance of climate change and climatic modelling for the area.

6.3.3 Physical risks within the value chain

As indicated above, the intensity and variability of rainfall is increasing, meaning that even though rainfall events will be unpredictable, when they do occur they will be more intense than normal. Such events could damage or wash away infrastructure or transport routes. This could negatively impact logistics, labour and the supply of products such as diesel, coal, iron ore and lime to the SEZ. The risk of supply chain disruptions for the construction phase of this project is medium, as the project is situated within a mining area which has sufficient stock levels of construction materials. The increased probability of storms may however impact the SEZ in terms of employee safety, infrastructure safety, production delays and increased insurance costs.

Based on information available for this study, it is assumed that the electricity for the construction phase will be supplied by Eskom. During the operational phase electricity will be provided by the thermal power plant. In terms of climate change impacts, there are two key considerations with regards to electricity derived from Eskom: the first being water and the second being the regulatory implications of the proposed carbon tax on the power utility.

During 2017 Eskom consumed 1.43 litres of water for every kWh of electricity produced[48]. The bulk of the Eskom power stations are situated in the Mpumalanga region which is a water stressed province. The overall water stress, as determined by the WRI Aqueduct, of the Mpumalanga region is "*Medium to High*" and is shown in the following Figure 26 below. In addition, climatic models predict that the province is going to become increasingly drier and hotter.

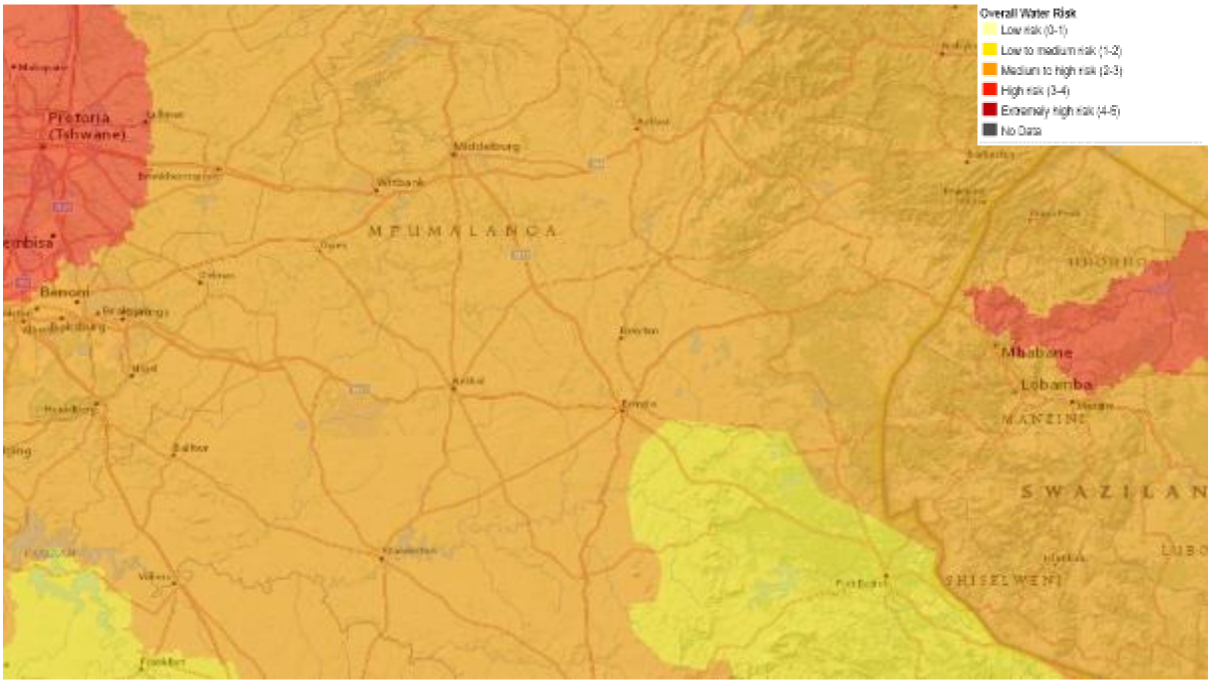

Figure 26: Overall water stress in Mpumalanga region[47].

Water scarcity and increasing constraints in terms of access to water could negatively impact Eskom's functionality. In turn, disruptions in Eskom's ability to generate power could negatively impact on the construction of the proposed SEZ's.

6.3.4 Disaster risks – flash flooding

The Makhado Local Municipality has seen an increase in the number of climate related disaster incidents over the past two years. This comes as a testament to the nature and variability that climate change imposes.

[48] Eskom, 2018. *Eskom Integrated Annual Report,* Johannesburg: Eskom.

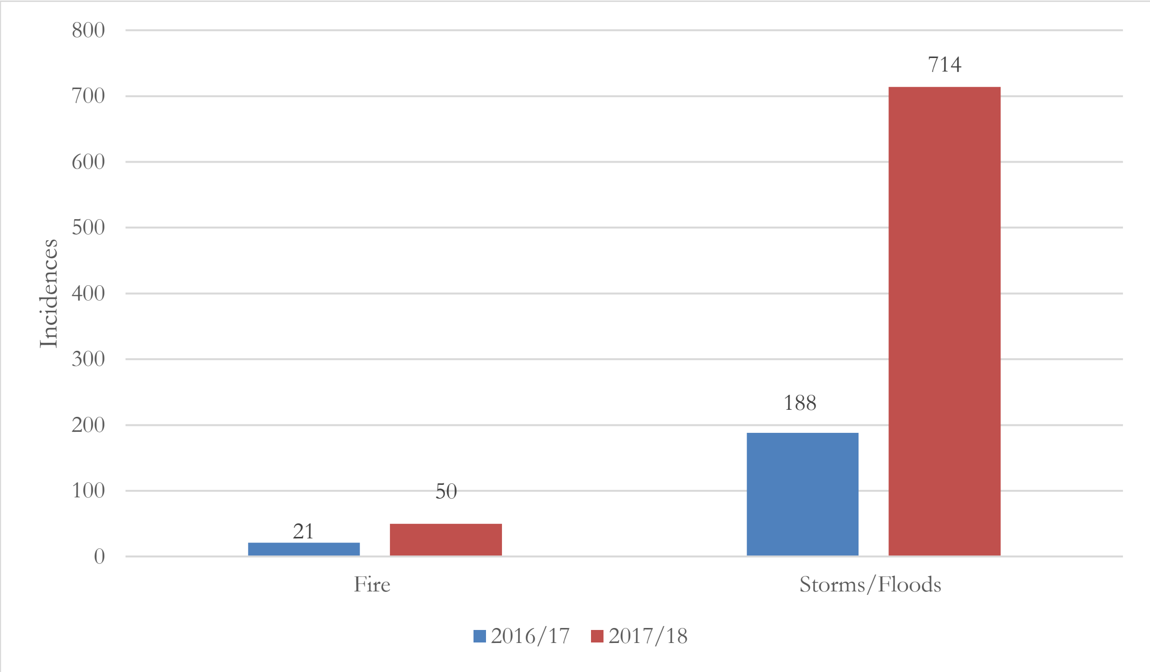

Figure 27: Disaster incidences from 2016 - 2018[49].

Climatic models for the Limpopo Province together with the WRI Aqueduct Tool indicate water as being a high-risk resource, especially in the context of climate change. Climate change impacts in the Limpopo Province include an increase in the number of extreme rainfall events- hailstorms, damaging winds, thunderstorms and flooding. This is due to the fact that even though the region is becoming dryer, the intensity of extreme rainfall days increases.

From Figure 10 in section 3.3.2.2 it is evident that the proposed SEZ is located in a medium to low flood hazard area. However, with a predicted increase in extreme rainfall days under RCP 8.5 for the period 2050, the risk of flash floods could pose significant risks to the safety of employees as well as causing operational disruptions at the SEZ which could lead to reduced output.

Furthermore, water is required for the facilities to function and is a key consideration in terms of employee and community safety. As such, it will be critical for the proposed SEZ to develop sufficient water buffering measures and water recycling methods to ensure the operations are sustainable. It is clear from the above, that the region is facing considerable climate change related disasters and the operations of the SEZ would need to be conducted in such a manner as to buffer against the effects that climate change may pose by implementing risk mitigation and adaptation actions.

[49] Makhado Local Municipality, 2018. *Makhado Local Municipality Draft Annual Report 2017/2018,* s.l.: s.n.

6.4 Social Impacts

The social context as part of this study refers to communities / settlements (both urban and rural) that would be impacted, both directly and indirectly, by the SEZ from a climate change point of view. In this regard the Vhembe District Municipality is an appropriate administrative boundary to define the social environment for the purposes of the climate change impact assessment for the proposed SEZ.

South Africa is particularly vulnerable to climate change because of its dependence on climate-sensitive economic sectors, high levels of poverty and the inter-related impacts of community health and service delivery challenges. Furthermore, climate change impacts and extreme weather events can affect some people or societal groups more than others.

The extent to which a person or a group will be affected will depend not only on their exposure to the event, 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 heatwaves as discussed in this report. Causes of social vulnerability to climate change in the case of the Musina and Makhado Local Municipality include, among others, informal housing, poverty, a high dependency ratio and limited/insufficient social infrastructure.

The analysis undertaken for this climate change impact study shows two key trends of specific relevance to socio economic context of the Vhembe District Municipality: declining rainfall patterns for the area and an increase in daily minimum average temperatures. These two trends will have a particularly challenging impacts on the Local Municipalities and their communities due to the prevalence of vulnerable groups within the area.

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. Elderly people, children younger than 12 months and people of poor health are particularly sensitive to these changes[50].

In addition to the above, prolonged dry periods and a lessening of annual rainfall could constrain water service delivery and limit access to potable water, specifically within informal communities. Makhado has the second highest number of informal dwellings in the Vhembe district illustrated in (Figure 28).

50 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.

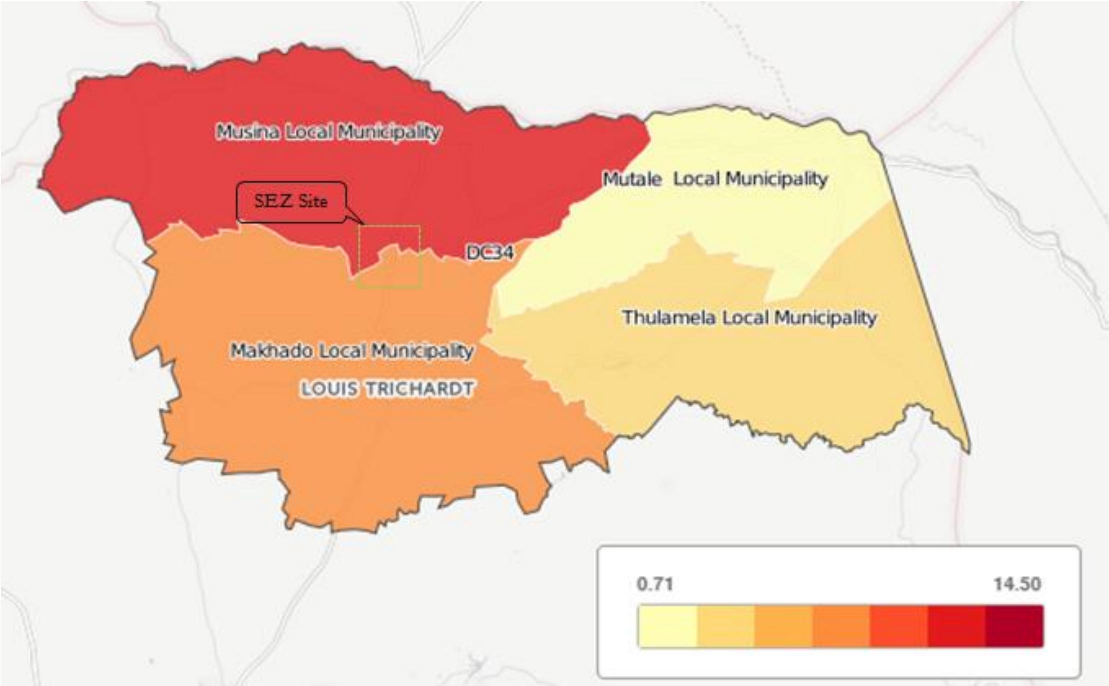

Figure 28: Percentage of households in informal dwellings in the Vhembe District Municipality[12].

Limited access to potable water, exacerbated by informal living conditions in some areas, could lead to an increased spread of water-borne diseases through unhealthy living conditions severely impacting existing vulnerable groups.

The relevance of these issues with regards to the proposed SEZ is that the Makhado Local Municipality has identified the industrial development as an economic opportunity for the area. As such, vulnerable communities will increasingly look to these industries for solutions, increasing social pressure and potentially impacting on the SEZ's social license to operate. In addition, due to the location of the SEZ, it could attract large numbers of migrant workers, further exacerbating current service delivery constraints within the District and Local Municipalities.

6.4.1 Description of local municipality socio-economic vulnerabilities

The Vhembe District Municipality is made up of four Local Municipalities, Musina, Makhado, Thulamela and Mutale. The Vhembe District Municipality is located in Limpopo which is South Africa's 5th largest province with a total land area of 125,755 square kilometres. The Vhembe District has a large agricultural economic sector and its rural population is dependent on agriculture for subsistence. Mining is the major economic driver in the province and contributes to more than a fifth of the province's economic growth. Approximately 1,294,722 people currently reside within the municipality and based on the vastness of the rural populace the municipality can be classified as predominately rural. Makhado has a greater population (558890) compared to Musina

(114690)[51]. An overview of key demographic details within Vhembe District Municipality is presented in Table 17 below.

Table 17: Vhembe District Municipality key demographic information (2011)[12].

General Information	Vhembe District Municipality	South Africa
Population	1,294,722	51,770,553
Age Structure		
Population under 15	34.88%	29.17%
Population 15 to 64	58.9%	44.30%
Population 40 to 64	17.11%	21.19%
Population over 65	6.27%	5.34%
Dependency Ratio		
People in age group 0-14 & 65+, supported by age group 15-64	69.9%	52.7%
Employment (between 15 and 64)		
Employed	24.85%	38.87%
Not economically active	50.79%	39.21%
Unemployed	15.68%	16.50%
Discouraged work-seeker	8.68%	5.41%
Education (aged 20 +)		
Post School Qualification	8.24%	9.94%
Grade 12/Matric	21.6%	27.83%
High School	33.39%	32.16%
Less than High School	15.48%	16.43%
Other	21.63%	13.64%
Vulnerability Indicators		
Household Dynamics		
Households	335,271	14,450,151
Percentage households involved in agricultural activities	41.00%	20.56%
Dwelling Type		
Health		
Percentage of young (<5yrs) and elderly (>64yrs)	18.93%	16.32%
Percentage workforce employed in the informal Sector	21.51%	12.20%

Key trends related to socio-economic context of the local municipality include the following:

- As evident in Vhembe District Municipality's Climate Change Vulnerability Assessment and Response Plan, climate change will impact the municipality's Local Economic

51 MMSEZ Progress Report Musina 16 July 2019. *Musina-Makhado Energy and Metallurgy Special Economic Zone, Socio-economic impact assessment.* Demacon.

Development Strategy. With the municipal population growing, further pressure will be placed on the demand for services and the overall regional economic base. This is especially the case in the agriculture, industrial and mining sectors which have been identified as key economic focus areas for the district.

- In terms of climate change, long-term hotter and drier conditions could negatively impact the agricultural sector and have further consequences on all communities which are dependent on agriculture for their livelihoods.
- There is a high dependency ratio within the Vhembe District Municipality. A high dependency ratio indicates that the economically active portion of the population in the municipality face a greater burden to support and provide the social services needed by those who are not economically active. Climate change will further increase the pressure on the portion of the population which is economically active through extreme weather events and thereby further increase the vulnerability of these communities.

The above-mentioned trends and related challenges, in terms of the impacts of climate change, can be exacerbated by high levels of poverty within the area. The population living in poverty is illustrated in Figure 29.

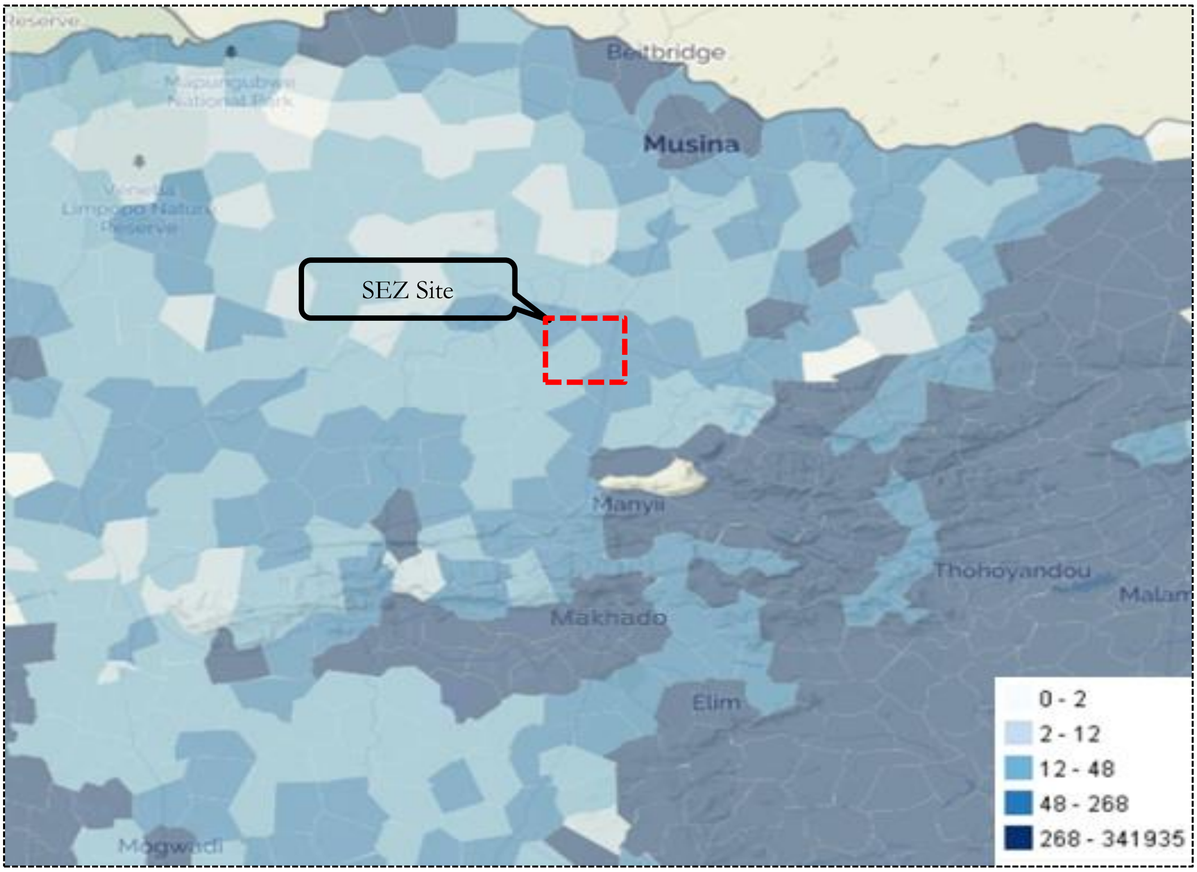

Figure 29: Population living in poverty[52].

[52] SA Risk and Vulnerability Atlas, 2019. *Socio-economic landscape.* Viewed 11 June 2019 http://sarva2.dirisa.org/atlas/socio-economic

According to the Makhado Local Municipality's Integrated Development Plan for 2018/19, 45.4% of the population were living in poverty in 2011[53]. This is an indication of a high level of community vulnerability within the area and the subsequent need for food and job security. Climate change will directly affect the sectors upon which the poor are dependent, which in this case is mining, agriculture and tourism and should be considered in this regard.

6.4.2 SEZ community vulnerability drivers

Vulnerability drivers impact the exposure, sensitivity and adaptive capacity of systems. The following are relevant vulnerability drivers for consideration pertaining to the proposed SEZ's communities and social aspects discussed above:

- Health - The health and safety of SEZ employees and the wider communities can be affected both directly and indirectly by a changing climate. Informal or less formal areas in the Vhembe District are specifically vulnerable to the spread of disease which can be driven by climate change. Long-term heat exposure can also exacerbate chronic diseases, including cardiovascular and respiratory disease, through indirect microbial and vector-borne pathways. Considering the backlog in service delivery; limited formal infrastructure and a growing population, the impact that climate change can have with regards to disease incidence is of a particular concern. This may impact SEZ employees who come from these areas and thus can have an impact on the operations of the SEZ.

- Wildlife and agriculture – Wildlife and agriculture is an important economic sector within the Musina and Makhado areas. The proposed SEZ site is surrounded by wildlife tourism and agricultural practices, ranging from commercial to subsistence-based practices. Changing climatic conditions will impact the ability of the already vulnerable surrounding communities to develop alternate or subsistence-based means of income. Social unrest and community dependency on the proposed SEZ could impact the operations and increase unplanned social expenditure

- Water - Water is an essential community service and essential for community wellbeing. With projections of increased rainfall variability, increasing drought occurrences, increase in clean water scarcity and an overall prediction of decreasing rainfall as described in section 6.2, climate change threatens the wellbeing of surrounding communities.

- Living conditions - The less developed nature of settlements, such as some of the communities surrounding the proposed SEZ in the Makhado and Musina Local Municipalities, are characterised by service delivery pressure. This is further heightened by tensions around the need for a better quality of life and living condition. In this regard it is critical to consider the social context in terms of understanding potential operational risks that the SEZ are exposed to.

As such, based on the above vulnerability drivers, there are three key issues which could influence the proposed SEZ once operational. These are summarised as follows:

[53] Makhado Local Municipality, 2018. *Makhado Local Municipality Integrated Development Plan 2018-2019 Review,* s.l.: s.n.

- Amplified community dependence on the SEZ for service delivery. This could increase social expenditure and result in unsustainable social spending and the possible stimulation of unsustainable growth of this area.

- Strained service capacity, for example due to possible in-migration to the area and as a result of climatic events which has result in resource shortages. Water is a particularly sensitive resource within the area which is categorised as water stressed. Additionally, water impacts, either upstream or downstream from the SEZ's operations, could result in community volatility and reputational damage to the SEZ. Furthermore, such volatility is not limited locally as water supply is planned to be source from Zimbabwe and thereby having international consequences.

- Negative impacts on well-being of employees in terms of climate related impacts could result in a less productive workforce. As described earlier, vulnerable communities are more susceptible to climate induced livelihood impacts such as disease spread, heat stress and clean water scarcity due to drought and low rainfall.

Related to the above key issues, the following **Error! Reference source not found.** provides an overview of the climate change manifestations, impacts on the broader network of the SEZ and the typical impacts that these could have.

Table 18: Climate change manifestation, community impacts and operational influence[54]

Climate change manifestation	Impact	Possible SEZ Impacts					
		Increased community dependence	Increased social expenditure	Operational efficiency	Community volatility	Reputational damage	Dangerous working conditions
High daily maximum averages coupled with increasing daily average minimum temperatures.	➔ Increased temperatures become dangerous for workers			✔			✔
	➔ Increased energy demand for cooling.	✔	✔		✔		✔
	➔ Declining air quality in the community – dust pollution if not adequately controlled and managed.				✔	✔	
Declining annual rainfall.	➔ Increased water demand.	✔	✔		✔	✔	✔
	➔ Water quality problems.	✔	✔		✔	✔	✔

[54] Promethium Carbon assessment

	➔ Reduction in quality of life of adjacent communities.	✔	✔	✔	✔	✔	✔
Increase in the variability of daily rainfall – higher daily average rainfall and expected to be more intense.	➔ Adverse effects on water supply.	✔	✔	✔	✔	✔	✔
	➔ Increased risk of death, injury, loss of property, and disease.				✔	✔	✔
	➔ Displacement of people and migration to urban areas.	✔	✔	✔	✔	✔	

Community challenges could impact political and economic decisions and give rise to protest and unrest at the SEZ. This could affect operations and the work force, as well as the company's social license to operate. As such, the impacts of climate change on the adjacent communities to the SEZ must be considered in terms of the physical risk considerations.

6.4.3 Human Health

Health is highlighted as a priority area of intervention in the Limpopo province due to the high levels of vulnerability to climate change. Of particular concern is the increase in temperatures which will have multiple health impacts and implications. For example, an increase in temperatures could lead to heat stress and dehydration. This will need to be considered by the SEZ as such conditions make the working conditions unsafe and unproductive. Increase in temperatures is also likely to cause an upsurge in vector borne diseases from the spread of mosquitoes, ticks, sand-flies, and blackflies. Rising temperatures will also cause an escalation of water borne and communicable diseases (typhoid fever, cholera and hepatitis). These diseases will affect the SEZ's labour force and influence the productivity of the facility.

Within the Vhembe District there are 21.51% percent of working individuals employed in the informal sector. As a result, the municipality has identified 'Increased Occupational Health' problems associated with temperature increases as a high sensitivity indicator due to the fact that the district has a low adaptive capacity to deal with these increases. Increased temperatures and extreme events such as heat waves are also likely to increase illnesses and injuries, especially for the Vhembe District which has a large proportion of the population having contracted HIV/AIDS and a high proportion of elderly in the area.

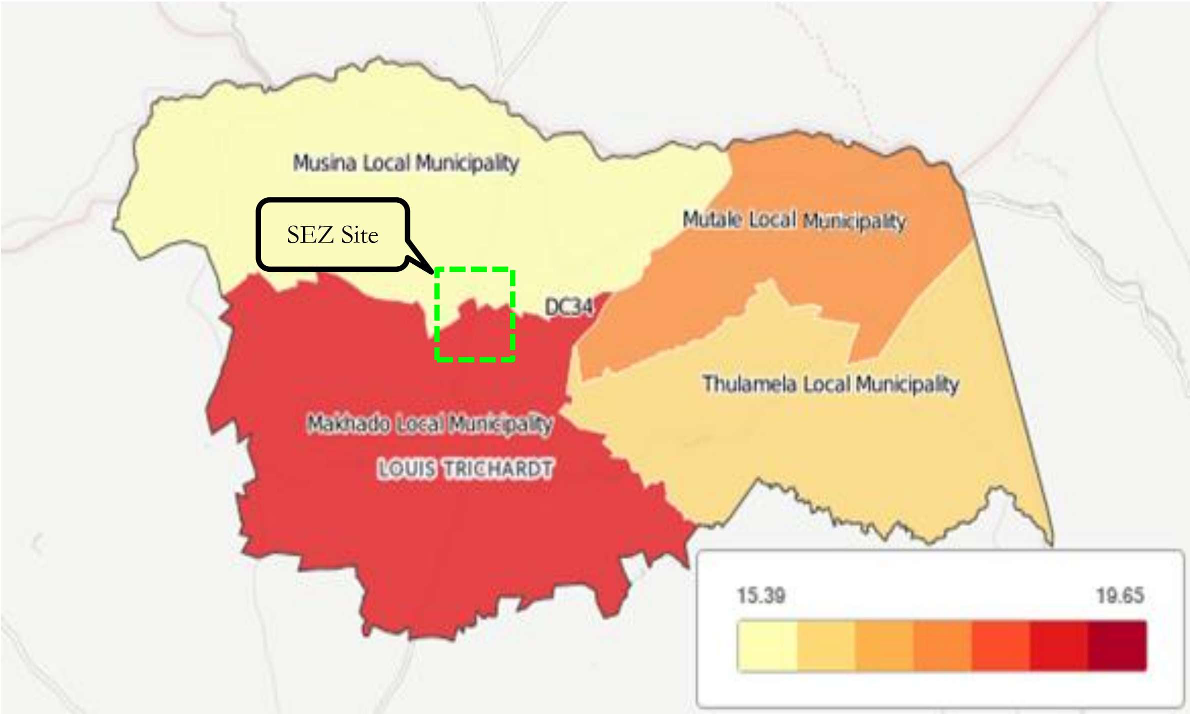

Figure 30: Vhembe district Municipality Percentage of Young (<5yrs) and elderly (>64yrs)[12].

Climate change impacts will also affect the provision of health services that communities in the district rely on. The district already experiences the following challenges with regards to provision of health services[12]:

- Lack of basic amenities including shade at clinic visiting points; shortages of medicine;
- Lack of dedicated pharmacists and assistant pharmacists;
- Influx of migrants from neighbouring countries;
- Malaria;
- Rabies;
- HIV and AIDS;
- Tuberculosis; and
- Poor road and communication networks to access healthcare.

These challenges in the provision of health services may become exacerbated by climate change impacts, where for instance extreme weather prevents can delay or prevent the distribution of necessary medication.

6.4.4 Human settlements

Climate change will have various impacts on human settlements. Increases in the severity of storm events and flooding could damage strategic infrastructure which may result in a loss of industrial productivity and service delivery disruptions. In terms of access to services in the district, the majority of households live in formal dwellings, with 2.43% of households living in informal dwellings and 9.48% living in traditional dwellings.

The impacts of storm events will particularly affect communities located in informal settlements around the SEZ. Households within flood plains where there is poor drainage infrastructure are particularly at risk, as communities will face damage as a result of flooding. Rural communities may also become more physically isolated due to extreme events impacting on key infrastructure, leading to increase trends of migration to urban and peri-urban areas. This may have an impact on the SEZ's labour force, as workers might not be able, or be willing to travel from developed urban areas to the SEZ.

6.4.5 Water and sanitation

Vhembe District Municipality is currently experiencing issues of water scarcity and quality. Climate change is expected to exacerbate these problems. Drought, reduced runoff, increased evaporation, and an increase in flood events will impact on both water quality and quantity. Enhanced evaporation rates have caused deterioration in water quality due to increased salt concentrations in dams, wetlands and soil/plant systems. Increased drought means less water is available to dilute wastewater discharges and irrigation return-flows to rivers. This results in reduced water quality and associated downstream health risks to aquatic ecosystems. These concerns result in less water being available for irrigation and drinking purposes, which impact negatively on the livelihoods of communities, especially in rural areas.

The Vhembe District Municipality is both the Water Services Authority and Provider. The main water challenges for the district include: the high water and sanitation backlog, upgrading of infrastructure, resource extension, operation and maintenance, as well as refurbishment needs. 27.93% of the district municipality's community lack access to piped water[12].

Furthermore, the Vhembe District Municipality's wastewater management has been assessed to be in a "critical" state, as the district received a 16.30% Green Drop System audit in 2011[12]. Additionally, there were no clean audits on municipalities in the Limpopo Province for the 2017/18 financial year which further highlights issues around water management in the area[55].

Critical state systems are more susceptible to the impacts of climate change where droughts will exasperate these issues through less water availability and as a result further impact the livelihoods of communities in the Vhembe District and therefore impact the SEZ.

6.4.6 In-migration risks

It is not only communities in close proximity to the SEZ that will be impacted as a result of climate change. The SEZ is strategically located in terms of access to South Africa's neighbours. The scale

[55] Daily Maverick, 2019. '*It's a systems breakdown across the country, with only 18 out of 257 municipalities receiving a clean audit.*, Viewed 26 July 2019 https://www.dailymaverick.co.za/article/2019-06-27-its-a-systems-breakdown-across-the-country-with-only-18-out-of-257-municipalities-receiving-a-clean-audit/

of the development, considering the social vulnerability of countries such as Zimbabwe and Mozambique, could attract large number so migrant workers. Climate change is likely to particularly affect socially vulnerable populations already inclined to migrate. Climate-related food insecurity, service incapacity and climatic impacts on subsistence based livelihoods lead to increased migration. The following figure illustrates climate related events and their impacts on Southern African countries.

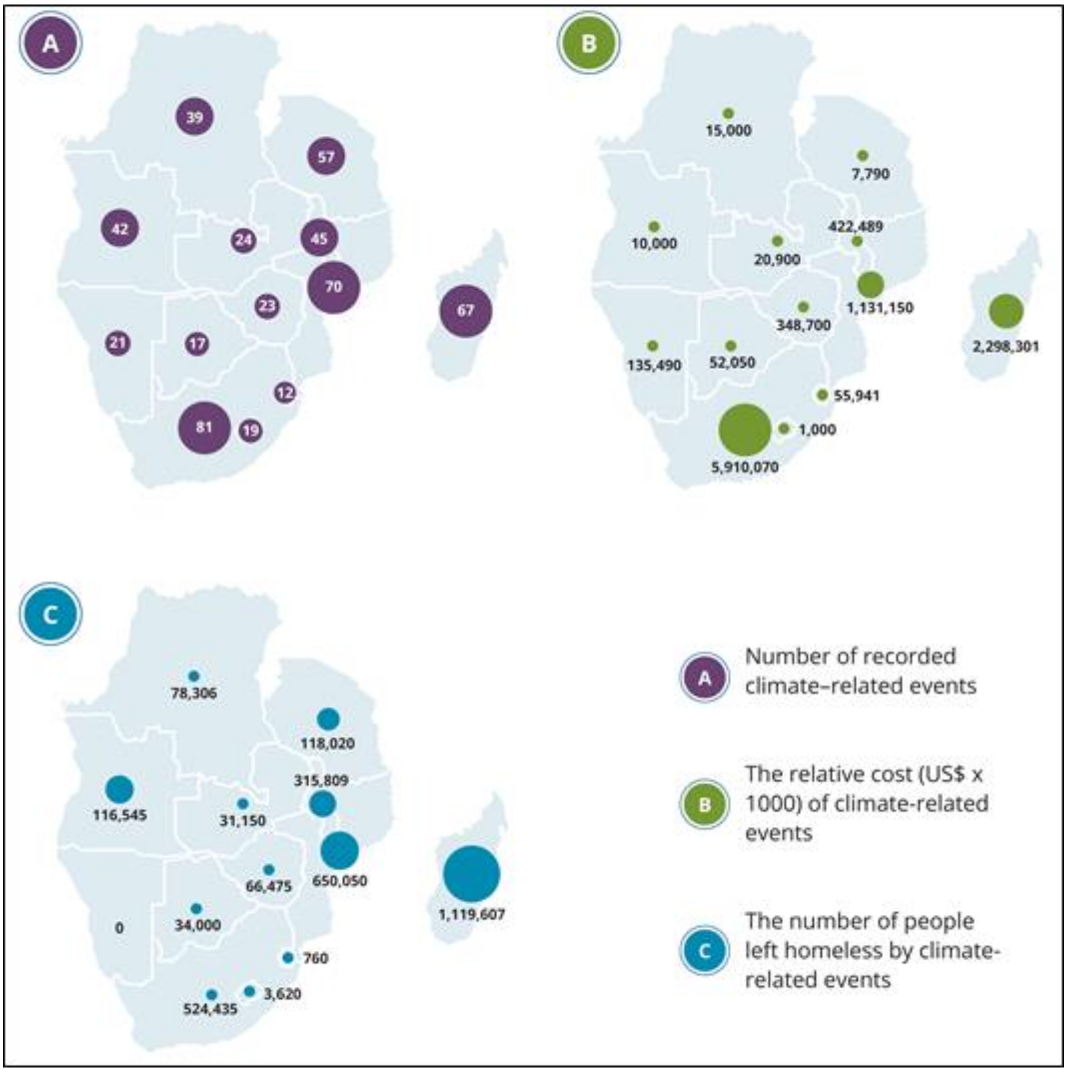

Figure 31: Summary of the climate-related events per country in southern Africa since 1980[56]

Although South Africa has the highest number of recorded climatological events and the highest economic cost of damages, the communities of Mozambique, Madagascar, and Malawi are particularly vulnerable to extreme climate events[62].

Mozambique is one of Africa's most vulnerable countries to climate change. Poverty, weak institutional development and frequent extreme weather events make Mozambique especially

56 CSIR, 2017. Climate Risk and Vulnerability: A Handbook for Southern Africa (2nd Edition). Davis-Reddy, C.L and Vincent, K

vulnerable[57]. Climate related hazards such as droughts, floods and cyclones are occurring with increasing frequency. This has a negative impact on a population that is already vulnerable in terms of institutional and infrastructure readiness. Central Mozambique is projected to experience recurrent agricultural losses as a result of droughts, floods, and uncontrolled bush fires. The densely populated coastal lowlands will be increasingly affected by erosion, saltwater intrusion, loss of vital infrastructure and the spread of diseases such as malaria, cholera and influenza[57].

Zimbabwe will face increasing drought conditions[62]. This will have a severe impact on the country's agricultural base and related capacities. Coupled with increasing socio-economic pressures and struggling institutional capacities, this country's population will be prone to migration.

The strain on communities in Mozambique and Zimbabwe as a result of climate change could increase migration to areas such as the local municipalities surrounding the SEZ. This could lead to community tensions as competition for land, water and basic services increase, further increasing the existing vulnerability of the local communities.

6.5 The Natural Environment

Ecosystem services, similar to the issue of water within the context of climate change and the nature of climate change impacts, is addressed from a regional perspective. Ecosystem services play a vital role in climate change adaptation, as such, it forms part of this climate change impact assessment. Ecosystem services, are considered to be 'nature's contribution to people', and can include the following functions[58]:

- Habitat creation and maintenance of genetic diversity;
- Moderation of extreme events: wetlands regulate flood waters and trees stabilise slopes and prevent erosion while maintaining soil fertility;
- Soil pollination reduction, plant propagation and biological control of pests and vector borne diseases;
- Regulation of climate: trees provide shade and regulate air quality by removing pollutants from the atmosphere;
- The provision of food, feed, energy, fresh water and raw materials;
- Physical and experimental interactions with nature, symbolic meaning and inspiration.

57 Netherlands Commission for Environmental Assessment (Dutch Sustainability Unit). Climate Change Profile: Mozambique.

58 Pascual, U. e. a., 2017. Valuing nature's contributions to people: the IPBES approach. *Current Opinion in Environmental Sustainability,* Volume 26, pp. 7-16.

Climate change as well as human activities are direct drivers of ecosystem change and could significantly impact vulnerable people, who often rely heavily on natural systems[59]. Therefore, a disruption in ecosystem services due to climate change can have an impact on the people who rely on the ecosystem for their livelihoods. This is reiterated within the Vhembe District Municipality Climate Response Plan which indicates that the aquatic and terrestrial ecosystems of the Limpopo province are highly vulnerable to the impacts of climate change[5] and as a result exposure them to impacts which affect their livelihoods.

The degradation and loss of ecosystem services will most likely affect lower income and vulnerable people disproportionately and has the potential to be a significant barrier to reducing poverty[60]. The loss of natural systems as a result of climate change impacts in the region will exacerbate social vulnerabilities and could further increase the pressure on the proposed SEZ's social licence to operate.

6.5.1 Land use cover change

Land is a finite physical asset and cannot be reproduced. The latest IPCC report on land and climate change notes that *land is both a source and a sink of greenhouse gases (GHGs) and plays a key role in the exchange of energy, water and aerosols between the land surface and atmosphere*61. Land ecosystems and biodiversity are vulnerable to ongoing climate change and weather and climate extremes, to different extents. The report found that changes in land cover and the loss of natural vegetation, could affect regional climate and result in, *inter alia*, accentuated warming and increased intensity, frequency and duration of extreme events[61].

As mentioned, land is both a CO_2 sink as a well as source of CO_2 emissions as a result of land use change activities, such as infrastructure development. In this regard the loss of natural land cover contributes to climate change in two ways: Firstly, the loss of natural vegetation results in the loss of a natural carbon sink. Secondly, the use of land for large-scale development, such as the Musina Makhado SEZ, results in increased emissions.

In addition, the loss of large tracts of land in terms of vegetation cover, could exacerbate existing land impacts related to climatic changes. Increased land surface air temperature and decreased precipitation, in conjunction with climate variability and human activities such as increased land use change through development, have contributed to desertification, specifically in the Southern African context. In addition, climate change can worsen land degradation through increased rainfall intensity, drought and heat. These climatic parameters are expected to manifest in the Vhembe District Municipality as a result of climate change.

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59 Howe, C. e. a., 2013. *Elucidating the pathways between climate change, ecosystem services and poverty alleviation*. Environmental Sustainability, Volume 5, p. 102 – 107.

60 Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Synthesis,* Washington, DC: Island Press.

61 IPCC, 2019. *IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse gas fluxes in Terrestrial Ecosystem: Summary for Policy Makers*. Intergovernmental Panel on Climate Change.

6.5.2 Biomes and ecosystem services

Vhembe District has a range of diverse ecosystems which support many threatened flora and fauna. These ecosystems include savanna, grasslands, indigenous forests, mountain escarpments (Soutpansberg) and numerous wetlands including a RAMSAR Wetland (Makuleke Wetland) in the North Eastern part of the Mutale Local Municipality. The savanna biome covers approximately 98% of the Vhembe District Municipality with the remainder being made up of forest (1%) and grassland (0.2%) biome. The impacts of climate change on South African biomes is depicted in Figure 32 below. The climate projections range from current, low (wet/cool climatic conditions), intermediate (median temperature and rainfall predictions) to high (dry/hot climatic conditions) scenarios.

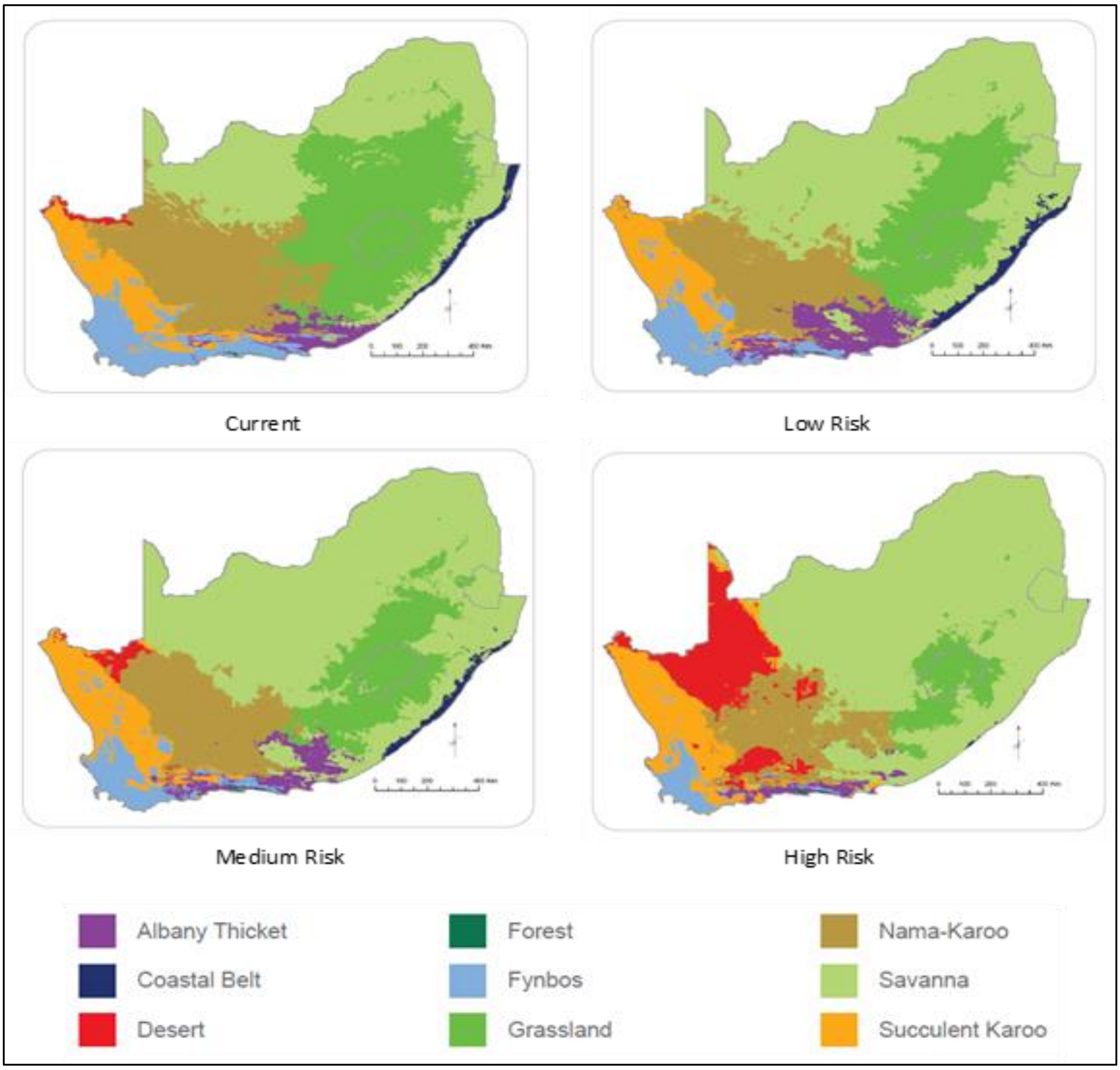

Figure 32: Bioclimatic envelope projections to 2050[22].

Common under each projection is that the climate envelope in Limpopo is likely to resemble a different biome in future. This means that the endemic biota of the biome could experience significant climate-related stresses. As illustrated in Figure 32above, the Grassland biome is likely to decline in the future across all the scenarios with the Savanna biome increasing in size. As a result, South Africa has identified Grasslands as the highest priority biome in terms of protection, restoration and conservation[22]. For the Limpopo and the Vhembe District however, Grasslands currently only contribute a small portion of the area and therefore these areas will not be as greatly impacted as opposed to for example, the Mpumalanga province. However, from a broader context, bush encroachment of woody plants into Grassland areas which are situated in water catchments may have an impact on water supply as this water management area transfers water to Limpopo. This will therefore also have implicated which impact water supply to the Vhembe District.

6.5.3 Drought

Increased frequency of veld fires associated with drought induced winds have shown to destroy entire habitats and threaten the biodiversity of these ecosystems. As a result, decreased rainfall events resulting in drought has been identified as an indirect threat to biodiversity in the Vhembe District[12]. This has been exasperated by the limited supply of ground and surface water in the District as well as increasing water demand for domestic, agricultural and mining purposes. Furthermore, it has been noted by the Vhembe District Municipality that existing water resources are being polluted by poor land management, poor sewage systems and agricultural pesticides resulting in less usable water. These issues will be of greater concern should the SEZ abstract ground and surface water from local water resources and thereby further limiting the amount of available water for the area.

6.6 Transitional Risks

The proposed SEZ tenants will have regulatory obligations associated with greenhouse gas emissions. Non-compliance with these regulations will carry penalties that will range from fines to criminal prosecutions.

Once operational, the SEZ tenants, as per the current Master Plan, will need to develop mandatory pollution prevention plans in accordance with the *National Pollution Prevention Plans Regulations*[62], published under the *National Environmental Management Act: Air Quality*. The SEZ will also be liable for reporting as per the *National Greenhouse Gas Emissions Reporting Regulations*[63]. In this event, the SEZ tenants will also be liable for carbon tax[64].

The gross tax rate is currently R 120/tCO_2e, however there are provisions for various allowances which reduce the effective tax rate to R 36/tCO_2e. The second phase of the Carbon Tax is will include a linkage to the national sectoral emission targets being developed by government. Once finalised, the sectoral emission targets may mandate eligible entities, potentially the SEZ, to develop carbon budgets within which they must operate or face penalties.

62 DEA, 2017c. *Declaration of Greenhouse Gases as Priority Air Pollutants,* s.l.: National Environmental Management: Air Quality Act, 2004.

63 DEA, 2017d. *National Greenhouse Gas Emission Reporting Regulations.,* s.l.: National Environmental Management: Air Quality Act, 2004..

64 The South African Carbon Tax Act No 15 of 2019 was signed and the Act gazetted on 23 May 2019 (Gazette No. 42483) and the law effective from 1 June 2019.

The new South African legislative framework will also carry cost-risks for the SEZ. The carbon tax payable by the SEZ tenants will be based on activity data reported to the Department of Environmental Affairs on an annual basis. The activity data relates to the consumption of the fossil fuels used by the SEZ tenants in their stationary equipment.

In terms of regulatory implications, indirect carbon tax implications will further increase operational costs for the SEZ with regards to carbon tax on diesel purchases which may be in the region of an additional ZAR 9c/litre.

During the construction phase, the SEZ will require building materials such as cement and steel. The prices of these products may increase with the introduction of the Carbon Tax Act 15 of 2019. This could ultimately increase the cost of construction for the SEZ. Furthermore, the carbon tax could potentially have an impact on the price of electricity. National Treasury has however given a commitment that there will be no impact of carbon tax on the electricity tariff up to 2022. After 2022 the carbon tax impact could be in the order of 5 cents per kWh, increasing to a potential level of 12 cents per kWh by 2030.

It is expected that increases in electricity costs will be passed on to consumers in the second phase carbon tax which will further increase the SEZ's construction phase costs in the order of 5 cents per kWh, increasing to a potential level of 12 cents per kWh by 2030. Costs of electricity could therefore increase by just under ZAR 1 million per year between 2022-2030 and by ZAR 2.3 million per year from 2030.

Lastly, finding 4 of Climate Policy Initiative on Understanding the impact of a low carbon transition on south Africa indicates '*The current South African system of incentives for new capital investment favour some existing industries that are exposed to transition risk, rather than new sectors that may create more sustainable sources of jobs and economic growth. Currently planned investment decisions could add more than $25 billion to the country's transition risk*'[65]. This indicates that investments into new assets such as infrastructure, mines and refineries could enhance the transitional risk faced by companies, investor and the government. This is particularly relevant if resultant lower future revenues under a 2°C scenario are insufficient to cover the investment cost and losses. This highlight the sustainability of such investments over industries or assets which are more resilient to transitional risk or which benefit from a low carbon transition.

[65] M, Huxham, M, Anwar, D Nelson, 2019. *Climate Policy Initiative. Understanding the impact of a low carbon transition on South Africa.* ACPI Energy Finance Report. Viewed 18 June 2019 https://climatepolicyinitiative.org/publication/understanding-the-impact-of-a-low-carbon-transition-on-south-africa/

6.7 Summary of climate change resilience assessment

The potential impacts of the different scenarios on the SEZ are summarised from the above section into Table 19 below.

Table 19: Potential impact analysis for the SEZ under RCP8.5.

Risks	Rating	Comments
Core Operations – SEZ		
Heat stress	High Risk	Average temperatures are predicted to raise by between 2.35 ˚C - 2.69˚C by 2050 with an increase in the number of hot days (>35 ˚C) of between 17 – 57 hot days. The culmination of increased average temperatures and heat stress can result in a greater number of people at risk of heat-related medical conditions. A temperature increase of 1.5˚C by the year 2100 could lead to a 2.2% drop in working hours[40].
Water Stress	High Risk	The SEZ is located within water stressed area that is currently experiencing issues of water scarcity and water quality. Climate change will exacerbate water issues in this area particularly with predicted increases in drought and rainfall variability. The SEZ has acknowledge these challenges and has envisage to source water from Zimbabwe to supplement water that is planned to be acquired from the Limpopo River. Climate change models predict under best and worst case scenarios that average annual rainfall will decrease in all catchments of which are to supply water the SEZ from Zimbabwe. This further highlights the water supply risks associated with the SEZ large water demand. Additionally, it has been noted by the Vhembe District Municipality that existing water resources are being polluted by poor land management, poor sewage systems and agricultural pesticides resulting in less usable water. These issues will be of greater concern should the SEZ abstract ground and surface water from local water resources and thereby further limiting the amount of usable water for the area.

Risks	Rating	Comments
Disaster risks - Flash Floods	Medium Risk	As indicated in Figure 10, there is a medium risk of flash flooding within the area of the SEZ with a high risk of flooding within the Makhado and Soutpansberg escarpment area. Figure 27 indicates the increase in disaster weather event in the past year. Flooding will additionally pose a risk by disrupting operations of the SEZ by impacting access to the site and may impact on the functionality of machinery. Furthermore, flooding will also bring with it safety concerns as well as a risk of structural damage to infrastructure
Disaster risks - Drought	High Risk	Figure 20 indicates that there is a large increase in drought tendencies predicted for the period 2035 -2064. Increased drought has been found to bring with it an increase in the frequency of strong winds which can carry veld fires and destroy habitats. Therefore, drought will not only be an operation risk from a water perspective but also an infrastructure and health risk for the SEZ through knock-on consequences such as veld fires.
Regulatory obligations	High Risk	The SEZ tenants will be liable for reporting emissions as per the *National Greenhouse Gas Emissions Reporting Regulations.* Non-compliance with these regulations will carry penalties that will range from fines to criminal prosecutions. As the SEZ is a large emitter of GHG emissions ensuring compliance will be critical. In this event, the SEZ tenants will also be liable for carbon tax and therefore having cost impactions during the operational phase. Carbon tax could also increase the construction costs as the cost of resource materials may increase to compensate for carbon tax liability.
Value Chain - SEZ		
Disrupted supply chain	High Risk	It is assumed that the electricity for the construction phase will be supplied by Eskom. In terms of climate change impacts, there are two key considerations with regards to electricity derived from Eskom: the first being water and the second being the regulatory implications of the proposed carbon tax on the power utility. Decreasing water availability and quality may negatively affect the SEZ's direct operations as well as the upstream and downstream value chain. The risk of supply chain disruptions for the construction phase of this project is medium, as the project is situated within a mining area which has sufficient stock levels of construction materials. However, the increased probability of storms may however impact the SEZ in

Risks	Rating	Comments
		terms of employee safety, infrastructure safety, production delays and increased insurance costs. Drought conditions and their impacts on the core operations, value chain and broader network may be further exacerbated as the proposed SEZ falls within a water stressed area. Therefore, water scarcity issues for pose a tremendous threat to a facility which is heavily dependent on water for operations.
Regulatory obligations	High Risk	The second phase of the Carbon Tax is will include a linkage to the national sectoral emission targets being developed by government. Once finalised, the sectoral emission targets may mandate eligible entities, potentially the SEZ, to develop carbon budgets within which they must operate or face penalties. Indirect carbon tax implications will further increase operational costs for the SEZ with regards to carbon tax on diesel purchases for example. Furthermore, the decarbonisation of Eskom's operations could potentially carry a pricing risk for electricity. The carbon tax could potentially have an impact on the price of electricity. It is expected that increases in electricity costs will be passed on to consumers in the second phase carbon tax which will further increase the SEZ's construction phase costs.
Social and Environmental context – Musina and Makhado Local Municipalities		
Community vulnerability	High Risk	South Africa is particularly vulnerable to climate change because of its dependence on climate-sensitive economic sectors, high levels of poverty and the inter-related impacts of community health and service delivery challenges. How badly a person or group will be affected will depend not only on their exposure to the event, 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 heatwaves as discussed in this report. Table 17**Error! Reference source not found.** indicates the key demographics and the social context for the Musina and Makhado Local Municipalities. Due to, poor service delivery, a high dependency ratio, insufficient social infrastructure, few people having received formal education and high levels of poverty and unemployment, the Musina and Makhado Local Municipality is considered highly vulnerable to the impacts of climate change.

Risks	Rating	Comments
Heat stress	High Risk	Health is highlighted as a priority area of intervention in the Limpopo province due to the high levels of vulnerability to climate change. Of particular concern is the increase in temperatures which will have multiple health impacts and implications. 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. Elderly people, children younger than 12 months and people of poor health are particularly sensitive to these changes. Considering that average temperatures and the number of hot days are expected to increase, there is a high heat risk for the Musina and Makhado Local Municipality. This is particularly concerning as the Municipality shows high levels of social vulnerability.
In-migration	High Risk	As evident in Vhembe District Municipality's Climate Change Vulnerability Assessment and Response Plan, climate change will impact the municipality's Local Economic Development Strategy. With the municipal population growing further pressure will be placed on demand for services and the overall regional economic base. This is especially the case in the agriculture, industrial and mining sectors which have been identified as key economic focus areas for the district. As such, vulnerable communities will increasingly look to these industries for solutions and increasing social pressure on the SEZ's social license to operate.
Water supply	High Risk	Climate change is expected to exacerbate the water scarcity and quality problems currently being experience in the area through drought, reduced runoff, increased evaporation, and an increase in flood events which have all been predicted to occur more frequently as described above. Enhanced evaporation rates will further cause the deterioration of water quality due to increased salt concentrations in dams, wetlands and soil/plant systems. Increased drought means less water is available to dilute wastewater discharges and irrigation return-flows to rivers. This results in reduced water quality and associated downstream health risks to aquatic ecosystems. These concerns result in less water being available for irrigation and drinking purposes, which impact negatively on the livelihoods of communities, especially in rural areas.

Risks	Rating	Comments
Ecosystem vulnerability	Medium Risk	Common under each projection is that the climate envelope in Limpopo is likely to resemble a different biome in future (Figure 32). This means that the endemic biota of the biome could experience significant climate-related stresses. Increased frequency of veld fires associated with drought induced winds have shown to destroy entire habitats and threaten the biodiversity of these ecosystems. With predictions indicating that drought and the number of hot days are expected to increase this will remain a concern for the area. Furthermore, drought has been exasperated by the limited supply of ground and surface water in the District. This is not expected to reduce as the population of the municipalities are expected to grow along with the fact that there will be a greater water demand for domestic, agricultural, industrial and mining purposes.

Under RCP 4.5 average annual temperatures are expected to increase to between 2.01˚C - 2.55˚C for the area where the SEZ is located. This is slightly lower than under RCP 8.5. Due to the social context of the Musina and Makhado Local Municipality, the above ratings will not significantly change with regards to the risks on the social and environmental contexts under RCP4.5. With regards to the impacts on the SEZ, the environmental setting of the area in which the SEZ is located is water stressed, prone to droughts and surrounded by vulnerable communities with respect to climate change impacts. As change in climate is expected to exacerbate these conditions, increases in average annual temperature of between 2.01˚C - 2.55˚C under RCP 4.5 will have similar impacts as under RCP 8.5 which indicates an increase of between 2.35 ˚C - 2.69˚C. Therefore, under RCP 4.5 the risk ratings will not significantly change.

7 Climate Change and the Possibility of Stranded Assets

The global economy is currently experiencing a 'carbon bubble'. The term 'carbon bubble' refers to the high-levels of extractable fossil fuels left in the earth compared to the low-levels of fossil fuel emissions that the earth's atmosphere can accommodate before catastrophic levels of climate change ensue. The carbon bubble concept is illustrated in the following
Figure 33.

The amount of coal in the global reserves accounts for 1,500-2,000 gigatons of CO_2e, whereas the amount of emissions that could still be emitted before reaching the 2^{0}C limit is less than 1,000 gigatons of CO_2e.

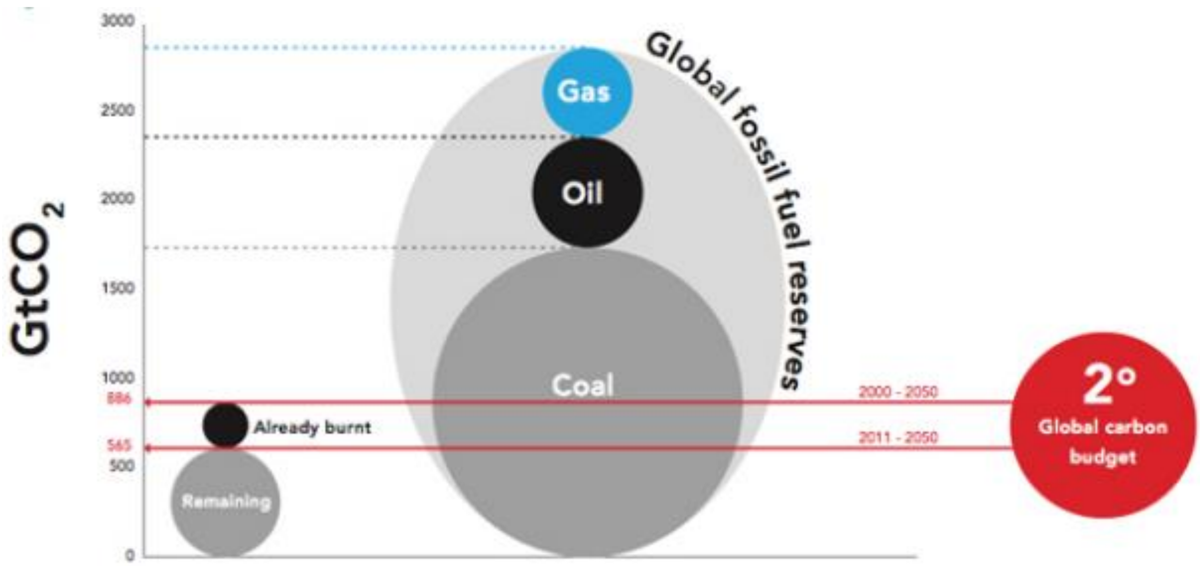

Figure 33: Comparison of the global 2°C carbon budget with fossil fuel reserves CO_2 emissions potential[66].

Current plans by governments to mitigate global greenhouse gas levels to levels that limit a 2^{0}C increase in global temperatures (compared to pre-industrial levels) are insufficient. The shortfall in country-level Intended Nationally Determined Contributions (precursors to the NDCs submitted under the Paris Agreement) is illustrated in the following Figure 34.

[66] Leaton, J., 2011. *Carbon bubble growing but markets aren't listening*. Viewed 25 July 2019 https://www.greenbiz.com/blog/2011/07/15/carbon-bubble-growing-markets-arent-listening

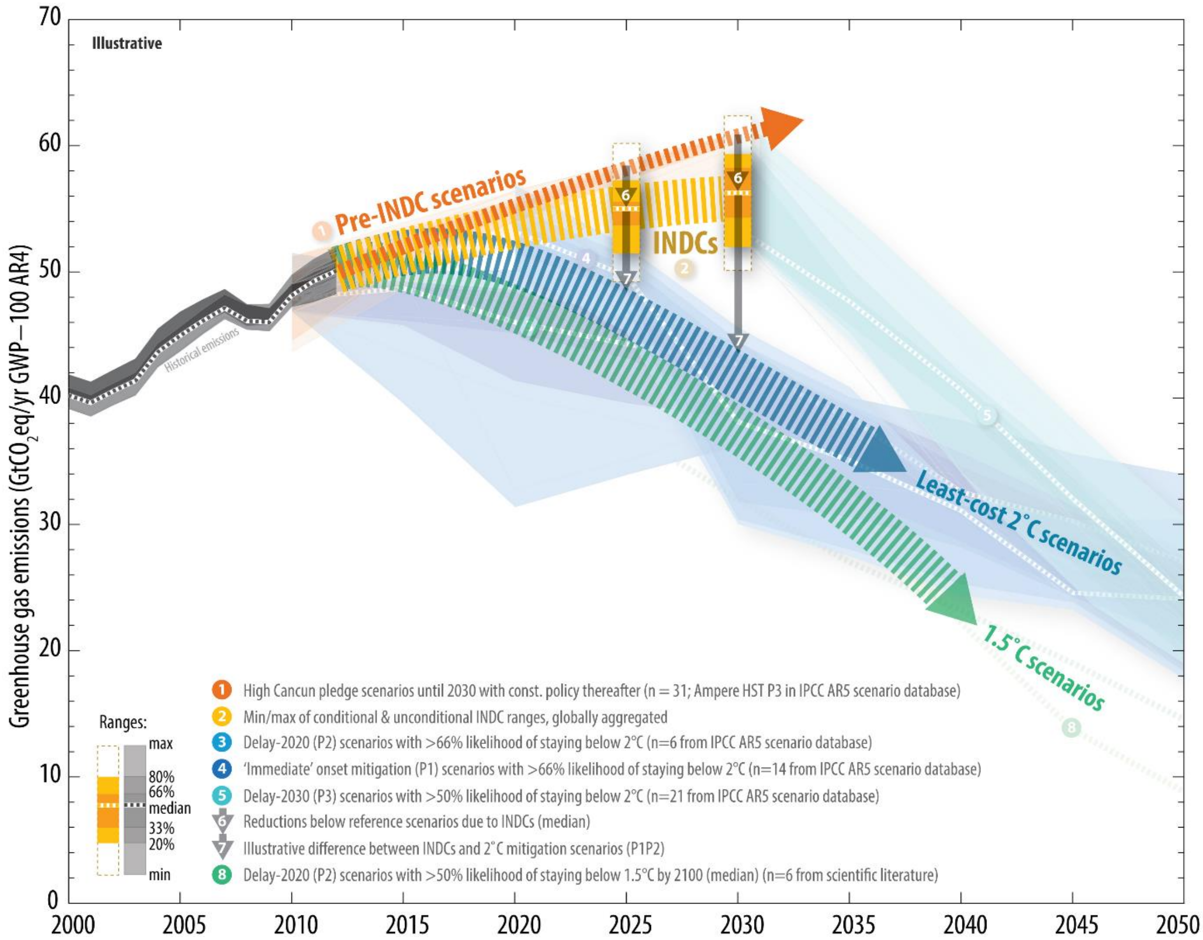

Figure 34: Shortfall in country level contributions to meet the 2^0C target[67].

The Paris Agreement takes cognisance of the initial shortfall in ambitions and provides for a ratcheting mechanism in which countries can increase the level of ambition of the NDCs. The ratcheting mechanism includes:

2015 Countries submitted their NDCs

2018 Countries took stock of collective efforts in relation to the long-term goal of the Paris Agreement. This stocktake will inform the preparation of the next round of pledges.

2020 Countries with 2025 targets to communicate their second round of climate pledges, while countries with 2030 targets will communicate or update their pledge. New climate pledges will then be submitted every five years.

2023 Global stocktake on mitigation, adaptation and finance.

2025 Countries to submit their third round of climate pledges

2028 Second global stocktake

The implication of the ratcheting mechanism is that countries that are party to the Paris Agreement (such as South Africa) will be increasing national targets to reduce greenhouse gas emissions over the next decade. National targets could increase pressures or penalties on emission intensive

[67] UNFCCC, 2016. *Aggregate effect of the intended nationally determined contributions: an update,* s.l.: United Nations.

businesses to limit greenhouse gas emissions, such as coal fire power stations and steel producers, both of which are proposed to be built within the SEZ.

The competitiveness of fossil fuel industries may be further threatened by cost reductions in renewable energies, particularly solar and wind. For example, between 2010-2017 the costs of onshore wind power fell by around 23% and solar photovoltaic electricity fell by 73% (Figure 35).

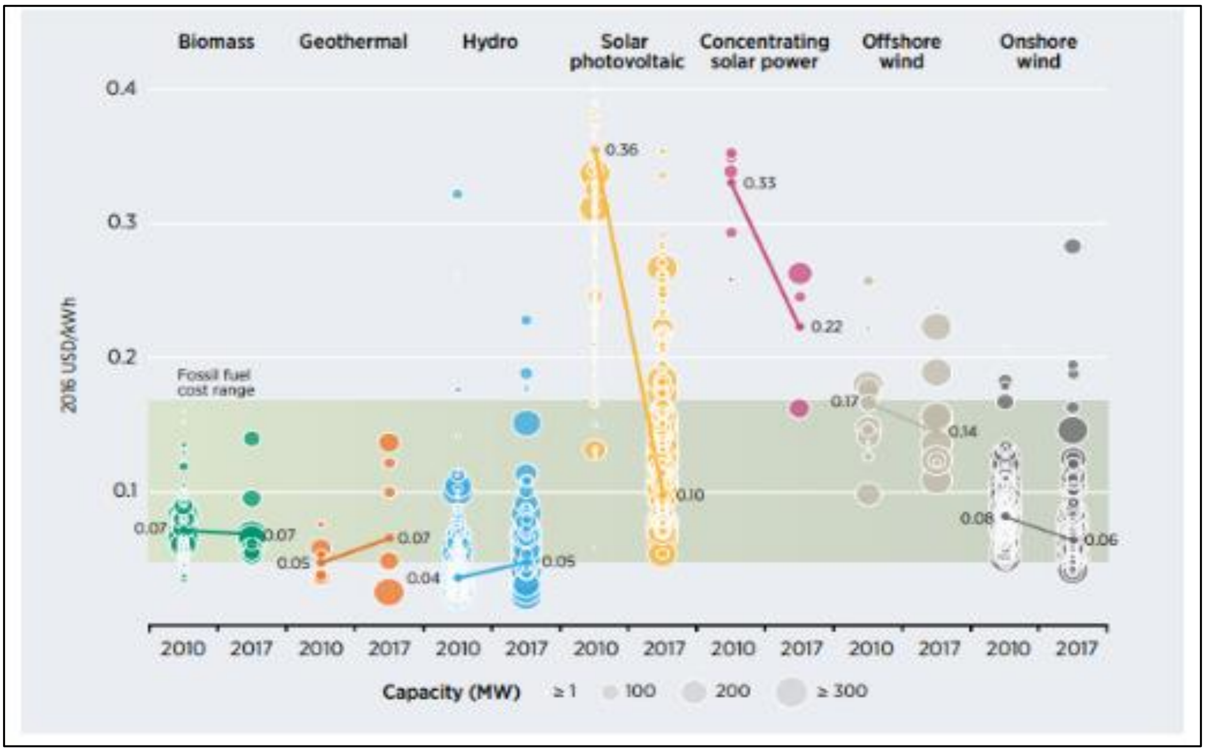

Figure 35: Global levelized cost of electricity from utility-scale renewable power generation technologies, 2010-2017[68].

It is expected that, by 2020, the renewable power generation technologies that are now in commercial use will fall within the fossil fuel-fired cost range. In most cases renewable energy will be cheaper than fossil fuels[68].

The proposed coal fired power plant at the SEZ may therefore be at risk of becoming a stranded asset considering the likelihood of the legal and commercial pressures related to increased national emission reduction targets and increased number of competitors in the energy space.

8 Mitigation and Adaptation

8.1 Design considerations

The majority of the SEZ emissions will occur during the operational phase. Therefore, emission mitigation measures would need to be focused on this phase to be effective in reducing the impacts the SEZ will have on climate change.

[68] IRENA, 2018. *Renewable power generation costs in 2017,* s.l.: IRENA.

Climate change mitigation is generally cantered round four main strategies:

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

For the SEZ, mitigation would be focused on two main aspects, energy efficient technologies and the use of renewable energies.

The mitigated emissions scenario is supported by the Paris Agreement and will be achieved as countries set ambitious NDCs (Nationally Determined Contributions). As countries work towards compiling their NDCs, additional regulations may be put in place to limit emissions from fossil fuel intensive industries or encourage renewable energy development. Evidence of this scenario were evident at the 24th Conference of the Parties (COP 24) held in Katowice, Poland in December 2018. The main issue under consideration at this event was global shortfall in targets to reach the goal of limiting average temperatures below 2 °C above pre-industrial levels. In this regard countries must negotiate and determine how to achieve such a target, and how to possibly accelerate efforts to achieve a 1.5°C target through a ratchet mechanism.

The ratchet mechanism requires countries to submit new NDCs every five years, outlining how much they intend to reduce emissions. Each submission should be more ambitious than the last. South Africa's NDC has been assessed as insufficient to meet a 2°C target. 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 projects such as the proposed SEZ.

8.2 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.

Projects implemented in the SEZ will be required to develop a pollution prevention plan, as there are a number is a listed production process in the *National Pollution Prevention Plans Regulations* published under the *National Environmental Management Act: Air Quality* which are applicable to the SEZ such as the production of iron, steel, ferro-alloys and electricity from fossil fuels.

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. This is particularly relevant to the production of iron, steel, ferro-alloys and electricity from fossil fuels, which will need to be reported to Department of Environmental Affairs. In this instance, such facilities would need to monitor and report their annual (calendar year) emissions associated with the combustion of fossil fuels in the stationary equipment.

9 Opinion on the Project

This project presents a unique challenge in that the results of this study differ if you look at it in different ways:

- When considered from a South African National perspective, the impacts of the project are:
  - The emission over the lifetime of the project will consume as much as 10% of the country's carbon budget. The impact on the emission inventory of the country is therefore HIGH.
  - The project cannot be implemented in the current regulatory confines when considering following:
    - The Nationally Determined Contribution (NDC) in terms of South Africa's commitment in terms of the Paris Agreement;
    - The Peak Plateau Decline (PPD) emission trajectory; and
    - The Integrated Resource Plan (IRP), which sets out the planned electricity production capacity of the country.
- When considered on an international level, the project could reduce emissions by as much as 10 million tons CO_2e per year, if the plants are built to the recommended emissions intensity specifications.

In the light of the above, our recommendations of the project are:

- Environmental authorisations for the individual plants in the SEZ should only be granted if the following emission intensities can be achieved:

Plant	**2°C target intensities for 2030**
Coke Plant	0.21 tCO_2e/tonne product
Ferrochrome plant	3.37 tCO_2e/tonne product
Ferromanganese plant	3.37 tCO_2e/tonne product
Silicon-manganese plant	5.18 tCO_2e/tonne product
Carbon steel plant	0.37 tCO_2e/tonne product
Stainless steel plant	0.78 tCO_2e/tonne product
Lime plant	0.87 tCO_2e/tonne product
Cement plant	0.80 tCO_2e/tonne clinker
Sewage treatment plant	0.0005 tCO_2e/tonne water
Water treatment plant	0.0005 tCO_2e/tonne water

- In addition, the environmental authorisation should require a re-assessment of the emission intensities 10 years after the start of operation of the respective plants

- The construction of a coal fired thermal power plant should not be approved unless the plant is fitted with a carbon capture and storage unit that can sequester all emission from the combustion of coal from the starting date of operation.
- The Specialist studies (groundwater, surface water, etc) for the environment authorisation for each plant in the overall SEZ should specifically address the impact of climate change on each area. For example, the ground water study should address the impact of climate change on the recharge of groundwater, etc. This is also important for all studies related to the social impacts of the projects.
- Water is of critical concern. The study area is already severely water stressed and climatic modelling for the area indicates increased ambient temperatures, prolonged periods of drought and greater rainfall variability. These factors will exacerbate current water risks, both in South Africa and in neighbouring Zimbabwe.
- The Vhembe District Municipality has a vulnerable population. This population is characterised by high levels of unemployment and low levels of education. In addition, there are significant service delivery backlogs within the area. Climate change could worsen the socio-economic conditions of these communities. In addition, due to the location and scale of the SEZ, and given the vulnerability of communities in Zimbabwe and Mozambique, the study area could see an increase in migratory job-seekers. This will further compound social pressures.