Climate Change Impact Assessment for the Proposed Kangala Colliery Extension (Eloff Project) near Delmas, Mpumalanga

Project done on behalf of **Environmental Impact Management Services (EIMS)**

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Report No: 18EIM09 | **Date:** November 2018

Report Details

Reference	18EIM09
Status	Scoping Report
Report Title	Climate Change Impact Assessment for the Proposed Kangala Colliery Extension (Eloff Project) near Delmas, Mpumalanga
Date	November 2018
Client	Environmental Impact Management Services (EIMS)
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Revision Record

Version	Date	Comments
Rev 0	November 2018	For client review

Competency Profiles

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NEMA Regulation (2014), Appendix 6

NEMA Regulations (2014) - Appendix 6	**Relevant section in report**
Details of the specialist who prepared the report.	Report details (page iii)
The expertise of that person to compile a specialist report including curriculum vitae.	Report details (page iii) Appendix A
A declaration that the person is independent in a form as may be specified by the competent authority.	Report details (page iii)
An indication of the scope of, and the purpose for which, the report was prepared.	Section 1: Introduction Section 1.1: Scope of Work
The date and season of the site investigation and the relevance of the season to the outcome of the assessment.	Not applicable
A description of the methodology adopted in preparing the report or carrying out the specialised process.	Section 1.1: Scope of Work Section 1.4: Impact Assessment Methodology
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure.	Section 2: Biophysical and Socioeconomic Environment
An identification of any areas to be avoided, including buffers.	Not applicable
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers.	Not applicable
A description of any assumptions made and any uncertainties or gaps in knowledge.	Section 1.5: Exclusions and Assumptions
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment.	Section 4: Conclusions.
Any mitigation measures for inclusion in the environmental management programme report	Section 3.4: Adaptation and Management Measures
Any conditions for inclusion in the environmental authorisation	Section 1.3.2: South African Legislation pertinent to the Current Study
Any monitoring requirements for inclusion in the environmental management programme report or environmental authorisation.	Not applicable
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised.	Section 4: Conclusion
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the environmental management programme report, and where applicable, the closure plan.	Section 3.4: Adaptation and Management Measures Section 4.1: Recommendations
A description of any consultation process that was undertaken during the course of carrying out the study.	Not applicable
A summary and copies if any comments that were received during any consultation process.	Not applicable.
Any other information requested by the competent authority.	Not applicable.

Executive Summary

A climate change impact study was conducted for the proposed opencast Kangala Colliery Extension (Eloff Project), which will be the life extension of Kangala from 2020 when the coal reserves at Kangala are depleted. Airshed was appointed to calculate the carbon footprint and determine the GHG emissions arising from the operations of the Eloff Project. The requirement is in preparation for the proposed carbon taxation which is likely to take effect as of next year, and to comply with the National Greenhouse Gas Emissions Reporting Regulations (NGER) which requires all coal mines to account for the amounts of pollutants discharged into the atmosphere (total emissions for one or more specific GHG pollutants) by 31 March each year.

The main findings were the following:

- The total CO_2-e emissions for the Eloff project operations is approximately 62 tpa, of which 76% is due to vehicle exhaust emissions and 24% is due to electricity consumption.
- The GHG emissions from the project are **low** and will not likely result in a noteworthy contribution to climate change on its own.
- The project and the community are likely to be negatively impacted by climate change, the project less so than the community, firstly due to the short time over which operations are planned to occur, and secondly because the project has measures in place to cope with the possibility of water shortage (likely to be the most significant problem faced) due to the up-sizing of the CHPP.
- The project and the community are likely to be negatively impacted by climate change due to increased temperatures and possible water shortages (decreased rainfall and possible increased evaporation). The community is estimated to have a moderate to high vulnerability to climate change, based on poverty, literacy, HIV prevalence, prevalence of malnutrition among children aged less than 5, access to facilities and access to services.

Recommendations

- The following is recommended to reduce the GHG emissions from project:
    - Ensuring the vehicles and equipment is maintained through an effective inspection and maintenance program.
    - Limiting the removal or vegetation and ensuring adequate re-vegetation or addition of vegetation surrounding the project. Vegetation acts as a carbon sink.
- The following is recommended to reduce the impacts of climate change on the project and the community:
    - Additional support infrastructure can reduce the climate change impact on the staff and project, for example the addition/upgrading of an on-site clinic, ensuring adequate water supply for staff and reducing on-site water usage as much as possible.
    - UCD1 could initiate a community development program if one is not already in place.

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Abbreviations

Airshed	Airshed Planning Professionals (Pty) Ltd
AQSR	Air Quality Sensitive Receptors
CCAM	Conformal-cubic atmospheric model
CCRA	Climate Change Reference Atlas
CCS	Carbon Capture and Storage
CE	Control Efficiency
CHPP	Coal Handling and Processing Plant
CMM	Coal mine methane
CTPP	Carbon Tax Policy Paper
DEA	Department of Environmental Affairs
EC	European Commission
FOLU	Forestry and Other Land Use
GCM	Global Climate Change
GHG	Greenhouse gas
GHGIP	Greenhouse Gas Improvement Programme
IFC	International Finance Corporation
INDC	Intended nationally determined contributions
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IT	Interim target
Ltd	Limited
NAAQS	National Ambient Air Quality Standards
NAEIS	National Atmospheric Emissions Inventory System
NCCRP	National Climate Change Response Plan
NDC	Nationally determined contributions
NGER	National Greenhouse Gas Emissions Reporting Regulations
Pty	Proprietary
RCP	Representative Concentration Pathway
REI4P	Renewable Energy Independent Power Producer Procurement Programme
ROM	Run-of-mine
SAAELIP	South African Atmospheric Emission Licensing and Inventory Portal
SAAQIS	South African Air Quality Information System
SCC	Social Cost of Carbon
UCD1	Universal Coal Development 1
UNFCC	United Nations Framework Convention on Climate Change
USBM	US Bureau of Mines
US EPA	United States Environmental Protection Agency

Glossary

Atmospheric dispersion model	A mathematical representation of the physics governing the dispersion of pollutants in the atmosphere
Atmospheric stability	A measure of the propensity for vertical motion in the atmosphere
Calm / stagnation	A period when wind speeds of less than 0.5 m/s persist
Cartesian grid	A co-ordinate system whose axes are straight lines intersecting at right angles
Dispersion	The lowering of the concentration of pollutants by the combined processes of advection and diffusion

Symbols and Units

Br	Bromine
Cd	Cadmium
CH_4	Methane
cm	centimetre
Co	Cobalt
CO	Carbon monoxide
CO_2	Carbon dioxide
Cr	Chromium
Cu	Copper
Fe	Iron
HCs	Hydrocarbons
km	Kilometre
mm	Millimetre
m	Metre
m^2	Metre squared
m^3	Metre cubed
m/s	Metres per second
Mg	Megagram, or tonne
Mn	Manganese
Ni	Nickel
NO	Nitrogen monoxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
Pb	Lead
PM	Particulate matter
$PM_{2.5}$	Particulate matter less than 2.5 µm in diameter
PM_{10}	Particulate matter less than 10 µm in diameter
SO_2	Sulfur dioxide
Ti	Titanium
tpa	Tonnes per annum
tpm	Tonnes per month
TSP	Total suspended particulates
V	Vanadium
VOC	Volatile Organic Compound
°C	Degrees Celsius
$\mu g/m^3$	Micrograms per cubic metre (concentration)

µm	Micrometre
%	Percent
Zn	Zinc
Zr	Zirconium

Climate Change Impact Assessment for the Proposed Kangala Colliery Extension (Eloff Project) near Delmas, Mpumalanga

1 INTRODUCTION

Universal Coal Development 1 (UCD1) wishes to apply for an environmental authorisation in support of the development of a new coal mining operation, known as the proposed Kangala Extension Project, or Eloff Project. Kangala has been an operating mine since April 2014. Eloff will be the life extension of Kangala from 2020 when the coal reserves at Kangala are depleted. Kangala Colliery is located 65 km due east of Johannesburg and 8.0 km south-west of the town of Delmas, in the Victor Khanye Local Municipality and the Nkangala District Municipality, Mpumalanga Province (Figure 1). The Eloff Project mining area is contiguous to the Kangala area and is situated close to the R42 provincial road and to the south of the R555 road. The proposed Eloff Project is anticipated to use a standard truck and shovel mining method based on strip mining design and layout. The existing Coal Handling and Processing Plant (CHPP) at Kangala Colliery will be utilised for the proposed Eloff Project.

The proposed activities will result in greenhouse gas impacts in the study area. Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed to calculate the carbon footprint and determine the greenhouse gas (GHG) emissions arising from the operations of the Eloff Project. The requirement is in preparation for the proposed carbon taxation which is likely to take effect as of next year. An updated draft carbon tax bill was introduced in December 2017 (Minister of Finance, 2017) to provide for the imposition of a tax on the carbon dioxide equivalent (CO_2eq) of GHG emissions.

As well as for carbon taxation, GHG emissions are also required to be reported for the National Greenhouse Gas Emissions Reporting Regulations (NGER) (Department of Environmental Affairs, 2017a). All coal mines are required to account for the mass of pollutants discharged into the atmosphere (total emissions for one or more specific GHG pollutants) by 31 March each year.

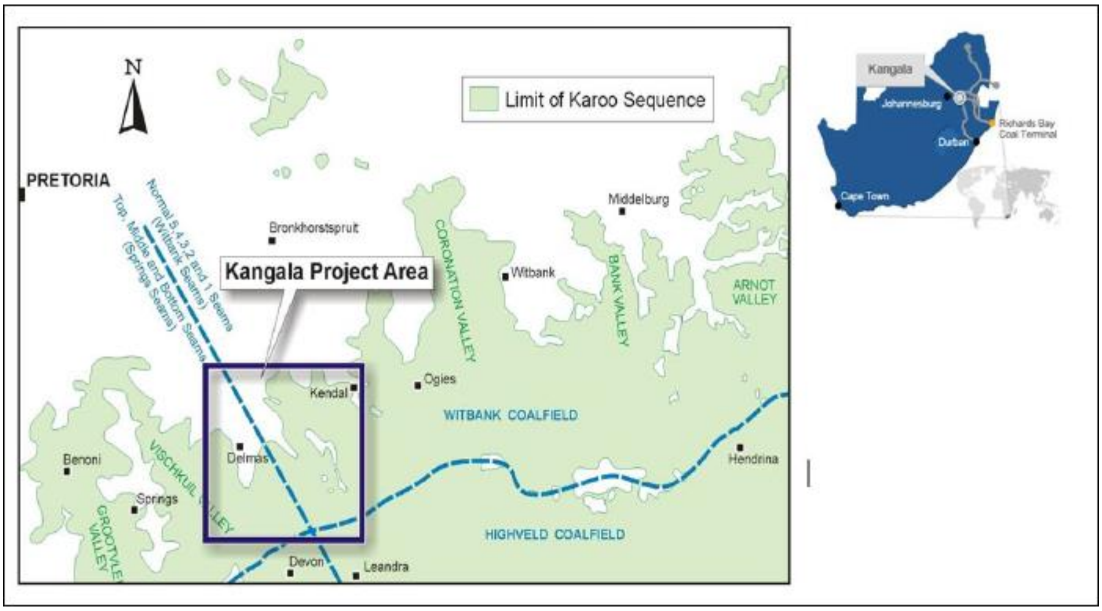

Figure 1: Kangala project area

1.1 Scope of Work

The climate change impact study will likely include the following tasks:

i. Quantification of the GHG emissions during the construction, operation and decommissioning of the project compared to the global and national (if available) emission inventory; and compared to international benchmarks for the project.
ii. The robustness of the project, with the impact of climate change over the lifetime of the project taken into account.
iii. The vulnerability of communities in the immediate vicinity of the project to climate change.
iv. Proposed management and mitigation strategies.

1.2 Greenhouse Gas Emissions from Coal Mining Activities

1.2.1 Opencast Coal Mining Activities that Result in GHG Emissions

The opencast coal mining process starts with land clearing for the removal of vegetation and topsoil by using bulldozers and scrapers, which may create damage to soil quality and vegetation as well as release large amounts of dust (Ghose, 2007). After land clearing, drilling and blasting are performed to reach the coal seam. Vertical blast holes are drilled from the surface and vary in diameter from 25 to 100 cm. In some mines, horizontal holes are drilled into the overburden with the drill sitting on the coal surface. The holes are generally charged with explosives that are a mixture of ammonium nitrate and fuel oil in dry mix, slurry, or emulsion forms. Often in practice, large quantities of nitrogen dioxide (NO_2) are released from blasts, which are observed as intense orange plumes (Pandey and Gautam, 2017).

After drilling and blasting of hard overburden, when the coal seam is exposed, the block of coal may be drilled and blasted (if hard) which releases coal dust. Coal dust itself acts as a medium for transportation and dispersal of pollutants in the surface environment, and its chemical composition contains metals like Fe, Cu, Zn, Mn, Pb, Cd, Cr, Ni, Co, V, Ti, Br, Zr, etc., and organic pollutants (Pandey and Gautam, 2017). The sources of GHG emissions associated with coal mining activities are shown in Table 1.

Table 1: Typical sources of GHG emissions associated with coal mining (Pandey and Gautam, 2017)

Activity	Pollutants	Sources of GHG
Coal seam exploitation (mining emissions)	Coal dust, CO, NO_x, CO_2, methane (CH_4)[1] (see note below the table) and noise from opencast activities	Direct energy use (fuel combustion), indirect energy use (electricity consumption) and fugitive emissions
Mechanical coal preparation (post-mining emissions)	Coal dust, CO, NO_x, CO_2, CH_4 and noise from materials handling of ROM coal, coal preparation waste (stone, sludge, slime, sewage, flotation tailings) and used chemicals	Fugitive emissions
Transportation (post-mining emissions)	Noise and coal dust from electricity and diesel fuel	Direct energy use

[1] Coal mine methane (CMM) is the term given to the gas trapped in coal seams. The gas is released once the seams are mined and can then escape to the atmosphere. Lloyd and Cook (2005) measured the release of methane from surface mining in South African collieries, through (1) the collection of samples from exposed seams, drill holes and interburden strata; (2) sealing the samples in gas tight containers for transport and crushing in the laboratory to release the methane content; and (3) analysing the results using the standard USBM graphical method to determine lost gas volumes. They found that the combination of low seam-gas contents in the coals mined from surface, and the low concentration of methane in the seam gases, means that the contribution from surface mining of coal to greenhouse gas releases by the industry can effectively be ignored. Even if the seam-gas content were as high as 0.1m^3/t and the methane content were as high as 50% of the total seam gas, then the approximately 100Mt of coal plus intraburden mined annually would contribute <3000t (3Gg) CH_4/annum.

Activity	Pollutants	Sources of GHG
Low temperature oxidation	Once coal is exposed to oxygen in air, the coal oxidises to produce CO_2.	Fugitive emissions
Spontaneous combustion	On occasions, when the heat produced by low temperature oxidation is trapped, the temperature rises and an active fire may result (with rapid CO_2 formation)	Combustion emissions

1.3 Legislative Requirements

1.3.1 Legal Background

1.3.1.1 International agreements

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

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

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

The Paris Agreement's central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. To reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their own national objectives.

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

In 2018, Parties will take stock of the collective efforts in relation to progress towards the goal set in the Paris Agreement and to inform the preparation of NDCs. There will also be a global stocktake every 5 years to assess the collective progress towards achieving the purpose of the Agreement and to inform further individual actions by Parties.

As of August 2017, 158 Parties of the 197 Parties to the UNFCCC Convention, including South Africa, had ratified the Paris agreement. South Africa submitted its intended NDC (INDC) to the UNFCCC on 25 September 2016.

1.3.1.2 South Africa's Response to Climate Change

1.3.1.2.1 National Climate Change Response Policy 2011

South Africa ratified the UNFCCC in August 1997 and acceded to the Kyoto protocol in 2002, with effect from 2005. However, since South Africa is an Annex 1 country it implies no binding commitment to cap or reduce GHG emissions.

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

The White Paper also highlighted the co-benefit of reducing GHG emissions by improving air quality and reducing respiratory diseases by reducing ambient particulate matter, ozone and SO_2 concentrations to levels in compliance with NAAQS by 2020. In order to achieve these objectives, the DEA has appointed a service provider to establish a national GHG emissions inventory, which will report through SAAQIS.

1.3.1.2.2 Intended Nationally Determined Contribution

The South African Intended Nationally Determined Contribution (INDC) submission was completed in 2015. This was undertaken to comply with decision 1/CP.19 and 1/CP.20 of the Conference of the Parties to the UNFCC. This document describes South Africa's INDC on adaptation, mitigation and finance and investment necessities to undertake the resolutions.

As part of the adaption portion the following goals have been assembled:

1. Goal 1: Development and implementation a National Adaption Plan. The implementation of this will also result in the implementation of the National Climate Change Response Plan (NCCRP) as per the 2011 policy.
2. Goal 2: In the development of national, sub-national and sector strategy framework, climate concerns must be taken into consideration.
3. Goal 3: An official institutional function for climate change response planning and implementation needs to be assembled.
4. Goal 4: The creation of an early warning, vulnerability and adaptation monitoring system
5. Goal 5: Develop policy regarding vulnerability assessment and adaptation needs.
6. Goal 6: Disclosure of undertakings and costs with regards to past adaptation strategies.

As part of the mitigation portion the following have been or can be implemented:

- The approval of 79 (5 243 MW) renewable energy Independent Power Producer (IPP) projects as part of a Renewable Energy Independent Power Producer Procurement Programme (REI4P). An additional 6 300 MW is being deliberated.
- A "Green Fund" has been created to back green economy initiatives. This fund will be increased in the future to sustain and improve successful initiatives.
- It is intended that by 2050 electricity will be decarbonised.
- Carbon Capture and Sequestration (or Carbon Capture and Storage) (CCS) which is discussed in more detail in the mitigation section.

- To support the use of electric and hybrid electric vehicles.
- Reduction of emissions can be achieved through the use of energy efficient lighting; variable speed drives and efficient motors; energy efficient appliances; solar water heaters; electric and hybrid electric vehicles; solar PV; wind power; CCS; and advanced bio-energy.

1.3.1.2.3 Greenhouse Gas Emissions

On 21 July 2017 the Minister declared the following greenhouse gases as priority pollutants (Government Gazette 40996, Notice 710 of 2017):

- Carbon dioxide (CO_2);
- Methane (CH_4);
- Nitrous Oxide (N_2O);
- Hydrofluorocarbons (HFC's);
- Perfluorocarbons (PFC's); and
- Sulphur hexafluoride (SF6).

Regulations pertaining to GHG reporting using the NAEIS was published on 3 April 2017 (Government Gazette 40762, Notice 257 of 2017). The South African mandatory reporting guidelines focus on the reporting of Scope 1 emissions only. The three broad scopes for estimating GHG are:

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

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

The DEA is working together with local sectors to develop country specific emissions factors in certain areas; however, in the interim the Intergovernmental Panel on Climate Change's (IPCC) default emission figures may be used to populate the SAAQIS GHG emission factor database. These country specific emission factors will replace some of the default IPCC emission factors. Technical guidelines for GHG emission estimation have been issued.

Also, a draft carbon tax bill was introduced for a further round of public consultation. The Carbon Tax Policy Paper (CTPP) (Department of National Treasury, 2013) stated consideration will be given to sectors where the potential for emissions reduction is limited. Certain production processes indicated in Annexure A of the notice (Government Gazette No. 40996 dated 21 July 2017) with GHG in excess of 0.1 Mt, measured as $CO_{2\text{-eq}}$, are required to submit a pollution prevention plan to the Minister for approval. The Eloff project operations fall under "coal mining" production processes specified in Annexure A (Department Environmental Affairs, 2017b).

1.3.1.2.4 GHG Inventories

1.3.1.2.4.1 National GHG Emissions Inventory

South Africa is perceived as a global climate change contributor and is undertaking steps to mitigate and adapt to the changing climate. DEA is categorised as the lead climate change institution and is required to coordinate and manage climate related information such as development of mitigation, monitoring, adaption and evaluation strategies (DEA, 2014a). This includes the establishment and updating of the National GHG Inventory. The National Greenhouse Gas Improvement Programme (GHGIP) has been initiated; it includes sector specific targets to improve methodology and emission factors used for the different sectors and improving the availability of data.

The 2000 to 2010 National GHG Inventory was prepared using the 2006 IPCC Guidelines (IPCC, 2006). According to the National GHG Inventory (DEA, 2014a) the 2010 total GHG emissions were estimated at approximately 544.314 million metric tonnes CO_2-e (excluding Forestry and Other Land Use (FOLU)). This was a 21.1% increase from the 2000 total GHG emissions (excluding FOLU). FOLU is estimated to be a net carbon sink which reduces the 2010 GHG emissions to 518.239 million metric tonnes CO_2-e. The assessment (excluding FOLU) showed the main sectors contributing to GHG emissions in 2010 to be the energy industries (solid fuels); road transport; manufacturing industry and construction (solid fuels); and energy industries (liquid fuels). In 2010 the energy industry contributed 78.7% to the total GHG emissions (excluding FOLU), this increased by 3.6% from 2000.

1.3.1.2.4.2 GHG Emission Inventory for the Sector

The Eloff Project operations would most likely fall under the category of “industry” for the global GHG inventory and “manufacturing industries and construction” for the national GHG inventory. According to the “mitigation of climate change” document as part of the IPCC fifth Assessment Report (AR5) (IPCC, 2014) the 2010 global GHG emissions were 49 (±4.5) Gt CO_2-e, 21% (10 Gt CO_2-e) which is as a result of industry. This category contributes approximately 41.117 million metric tonnes CO_2-e (excluding and including FOLU).

1.3.2 South African Climate Change Legislation Pertinent to the Current Study

Based on the new GHG reporting regulations (Department Environmental Affairs, 2017a) UCD1 is required to:

1. Register all facilities where activities exceed the thresholds (for coal mining there is no threshold, so therefore the data provider has to report activity data and greenhouse gas emissions irrespective of the size of greenhouse gas emissions and the scale of the operation of the activity) listed in Annexure 1 by providing the relevant information as listed in Annexure 2 to these Regulations, within 30 days after the commencement of these Regulations or within 30 days after commencing such an activity after the commencement of these Regulations.
2. Ensure that the registration details are complete and are an accurate reflection of the IPCC emission sources at each facility.
3. The registration contemplated in sub-regulation (1) must be done as follows:
    i. on the NAEIS;
    ii. in cases where the NAEIS is unable to meet the registration requirements, the registration must be done by submitting the information specified in Annexure 2 in an electronic format to the competent authority.

The reporting requirements are:

1. Submit the greenhouse gas emissions and activity data as set out in the Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emissions by Industry (Department Environmental Affairs, 2017c) for each of the relevant greenhouse gases and IPCC emission sources specified in Annexure 1 to these Regulations for all of its facilities and in accordance with the data and format requirements specified in Annexure 3 to these Regulations for the preceding calendar year, to the competent authority by 31 March of each year.
2. Where the 31 March falls on a Saturday, Sunday or public holiday, the submission deadline is the next working day.
3. The reporting contemplated in sub-regulations (1) and (2) must be done as follows:
    i. on the NAEIS;
    ii. in cases where the NAEIS is unable to meet the reporting requirements, the reporting must be done by submitting the information specified in Annexure 3 in an electronic format to the competent authority.

Coal mining (code 1B1a as specified in Annexure 1) needs to report applying a tier 2 or tier 3 methodology after 5 years from the date of promulgation of the regulations. Tier 1 can be used in the first 5 years.

"Tier" means a method used for determining greenhouse gas emissions as defined by the "IPCC Guidelines for National Greenhouse Gas Inventories (2006)" and include–

i. Tier 1 method: A method using readily available statistical data on the intensity of processes (activity data) and IPCC emission factors (specified in the Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emissions by Industry or available in 2006 IPCC);
ii. Tier 2 method: similar to Tier 1 but uses country-specific emission factors;
iii. Tier 3 method: Tier 3 is any methodology more detailed than Tier 2 and might include amongst others, process models and direct measurements as specified in the 2006 IPCC guidelines.

It includes the quantification of greenhouse gases from all **direct** sources of emission associated with the process. The carbon footprint will exclude indirect GHG emissions. All emissions will be reported on as CO_2eq.

The technical guidelines (Department Environmental Affairs, 2017c) referenced by the NGER will be used for quantifying GHG inventories.

The anticipated carbon tax will be calculated based on the CO_2eq emissions.

1.4 Impact Assessment Methodology

As the emission of greenhouse gases has a global impact, it is not feasible to follow the normal impact assessment methodology viz. comparing the state of the physical environment after implementation of the project to the condition of the physical environment prior to its implementation. Instead, this report will assess the following

i. The GHG emissions/sequestration during the construction, operation and decommissioning of the project compared to the global and South African emission inventory and to international benchmarks for the project.
ii. The impact of climate change over the lifetime of the project taking the robustness of the project into account.
iii. The vulnerability of communities in the immediate vicinity of the project to climate change.
iv. Proposed mitigation and adaptation strategies.

1.4.1 Assessment of the Carbon Footprint and Carbon Sequestration

1.4.1.1 Carbon Emissions

The Carbon Footprint is an indication of the greenhouse gases estimated to be emitted directly and/or indirectly by an organisation, facility or product. It can be estimated from:

$$Carbon\ emissions = Activity\ information * emission\ factor * GWP$$

where

- *Activity information* relates to the activity that causes the emissions
- *Emission factor* refers to the amount of GHG emitted per unit of activity
- *GWP* or global warming potential is the potential of an emitted gas to cause global warming relative to CO_2. This converts the emissions of all GHGs to the equivalent amount of CO_2 or CO_2-e.

For combustion processes, the emission factor is often calculated from a carbon mass balance, where the combustion of each unit mass of carbon in the fuel leads to an equivalent emission of 3.67 mass units of CO_2 (from 44/12, the ratio of molecular weight of CO_2 to that of carbon).

This report considers Scope 1 emissions, which are the emissions directly attributable to the project, as well as Scope 2 emissions, which are the emissions associated with bought-in electricity over the lifetime of the project. Scope 3 emissions, which consider the "embedded" carbon in bought-in materials, are not considered here, in line with the guidelines provided by the International Finance Corporation (IFC, 2012).

1.4.1.2 Carbon Sequestration

Accounting for the uptake of carbon by plants, soils and water is referred to as *carbon sequestration* and these sources are commonly referred to as *carbon sinks*, because of their ability to absorb, as opposed to emit, GHG emissions. Quantifying the rate of carbon sequestration is however not a trivial task requiring detailed information on the geographical location, climate (specifically temperature and humidity) and species dominance (Ravin & Raine, 2007).

A carbon offset is a marketable commodity that represents the reduction in GHG emissions from a specific project undertaken by an organization (Ravin & Raine, 2007). Carbon offsets can be calculated by valuing the impact of the change in carbon sequestration in terms of the Social Cost of Carbon (SCC) of a tonne of CO_2 emitted. In order to be considered as a "carbon offset" project, a project must meet the criteria of *additionality,* i.e. the project must have resulted in GHG emission reductions or removals in addition to what would have occurred in its absence.

Practices and processes that sequester carbon dioxide from the atmosphere include (Ravin & Raine, 2007):

- Conservation of riparian buffers;
- Conservation tillage on croplands;
- Grazing land management;
- Afforestation;
- Reforestation;
- Forest preservation or avoided deforestation;
- Forest management;
- Underground geologic depositories; and
- Oceanic uptake.

1.4.2 Assessment of the Effect of Changing Climate Conditions on the Project

The aim of the assessment is to examine what kind of changes, threats and opportunities in an opencast mine and coal handling and processing plant might be encountered due to changing climatic conditions (Keränen *et al.*, 2012). The seasonal plan tool as used by Keränen *et al.* (2012) was used to portray climate scenario information according to changing seasonal circumstances.

1.4.3 Assessment of the Impact of Climate Change on the Surrounding Communities

Understanding a community's vulnerabilities to climate change is essential for informing decisions to adapt and reduce exposure to risk (City of Sarasota Climate Adaptation Plan, 2016). Vulnerability is the degree to which a system is susceptible to and unable to cope with adverse effects of climate change, including climate variability and extremes. The IPCC identifies three components of climate change vulnerability: exposure, sensitivity and adaptive capacity (CCA-RAI, 2014).

The following definitions apply (CCA-RAI, 2014):

- Exposure: Refers to 'the nature and degree to which a system is exposed to significant climatic variations.
- Sensitivity: Refers to 'the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli'. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise).
- Adaptive capacity: Refers to 'the ability of a system to adjust to climate change – including climate variability and extremes – to moderate potential damages, to take advantage of opportunities or to cope with the consequences'.

The relationship between vulnerability and its defining concepts is illustrated in Figure 2.

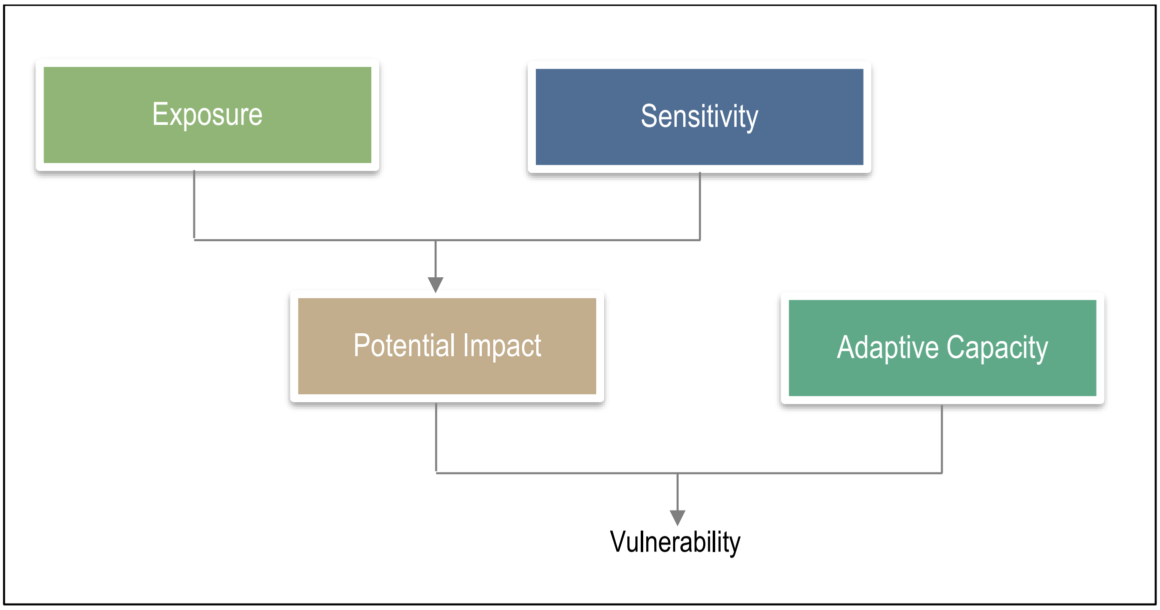

Figure 2: Relationship between vulnerability and its defining concepts (Source: CCA-RAI, 2014)

1.4.4 Adaptation and Mitigation Measures

Climate change management includes both mitigation and adaptation. The main aim of mitigation is to stabilise or reduce GHG concentrations as a result of anthropogenic activities. This is achievable by lessening sources (emissions) and/or enhancing sinks through human intervention.

1.5 Exclusions and Assumptions

No provision was made for:

- GHG emission estimation and impact assessment for the existing Kangala Colliery and nearby Middelbult Colliery.
- Meteorological monitoring;
- GHG sampling/monitoring;
- Site visits; and
- Meetings.

1.6 Report Outline

Section 2	Biophysical and Socioeconomic Environment
Section 3	Climate Change Impact Assessment
Section 4	Conclusions
Section 5	References
Section 6	Appendix A: Specialist Curriculum Vitae
Section 7	Appendix B: Climate Change Reference Atlas
Section 8	Appendix C: Projections of Future Climate Change over the Delmas Region in South Africa

2 BIOPHYSICAL AND SOCIOECONOMIC ENVIRONMENT

The objective of this section is to provide a description of the climate and socio-economic environment of the Eloff project area, and how it may be affected by climate change

2.1 Future Climate Projections for South Africa

The project area falls within the Highveld climatic zone which is characterised by moderate summers, cold winters and summer rainfall (Digby Wells Environmental, 2014). The near-future and far-future climate in Southern Africa was projected and published in a Climate Change Reference Atlas (CCRA) by the South African Weather Service (SAWS) in 2017 (http://www.weathersa.co.za/images/SAWS_CC_REFERENCE_ATLAS_PAGES.pdf), based on Global Climate Change Models (GCMs) projections and the Rossby Centre Regional Model (RCA4). Projected changes are defined relative to a historical 30-year period (1976 to 2005). A design description of the methodology employed in the climate change projections are given in Appendix B (Section 7.1). Their findings are listed below:

Low mitigation scenario (RCP8.5[2])

Near-future period (2036-2065) – This period is projected to be significantly warmer than the baseline period of 1976-2005. Most years are projected to be 2°C to 2.5°C warmer than the baseline average temperature. The seasonal average temperatures are expected to increase for all seasons, viz. 2°C to 2.5°C (summer and autumn) and 2.5°C to 3°C (winter and spring). The rainfall climatology is projected to remain variable, with some wet years projected to occur outside of that simulated for the baseline period (median change of 10 to 20mm more rainfall per year). The seasonal average rainfall is expected to increase in summer (10 to 20mm increase in rainfall) and decrease during the other seasons (5-10mm decrease in autumn, winter and spring).

Far-future period (2066-2095) – Further drastic warming is projected over the Delmas region for this period, with annual median temperature anomalies ranging between 4 and 4.5°C. The seasonal average temperatures are expected to increase for all seasons, viz. 3.5°C to 4°C (summer), 4°C to 4.5°C (autumn), and 4.5°C to 5°C (winter and spring). The region is also projected to become systematically drier (median change of 5 to 10mm less rainfall per year). The drastically higher temperatures may impact negatively on water availability from local dams due to higher evaporation rates. The seasonal average rainfall is expected to increase in summer 20 to 30mm increase in rainfall) and decrease during the other seasons (5-10mm decrease in autumn and winter, and 30 to 50mm decrease in spring).

Modest to high mitigation scenario (RCP4.5[3])

Near-future period (2036-2065) – Similar to that projected for the case of low mitigation in that most years are projected to be 1.5 °C to 2 °C warmer than the baseline average temperature. The seasonal average temperatures are expected to increase for all seasons, viz. 1.5°C to 2°C (summer and autumn) and 2°C to 2.5°C (winter and spring). The climate is projected to become drier (median change of 5 to 10mm less rainfall per year),

[2] Representative Concentration Pathway 8.5 (RCP8.5) (high pathway) is based on if no interventions to reduce GHG emissions are implemented (after 2100 the concentration is expected to continue to increase).

[3] RCP4.5 (medium to low pathway) is based on if current interventions to reduce GHG emissions are sustained (after 2100 the concentration is expected to stabilise or even decrease).

with likely fewer dry years than projected for the low mitigation scenario. The seasonal average rainfall is expected to increase in summer (5 to 10mm increase in rainfall) and decrease during the other seasons (0-5mm decrease in autumn and winter, and 10 to 20mm decrease in spring).

Far-future period (2066-2095) – Temperature changes in the Delmas region under modest- high mitigation are projected to range between 2.5°C and 3°C above that of the baseline climatology. The seasonal average temperatures are expected to increase for all seasons, viz. 2°C to 2.5°C (summer and autumn) and 2.5°C to 3°C (winter and spring). The climate is projected to become drier (median change of 0 to 5mm less rainfall per year), but with likely fewer dry years occurring when compared to the case of low mitigation. The seasonal average rainfall is expected to increase in summer (median increase of 20 to 30mm) and decrease during the other seasons (5-10mm decrease in autumn and winter, and 10 to 20mm decrease in spring).

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2.2 Socioeconomic Environment

The centre of economic activity in the Eloff project region is Delmas (Digby Wells Environmental, 2014), i.e. the residential receptor to the northeast of the project area (Figure 3). The largest sectors in terms of contribution to the local economy are trade, agriculture and mining. The local municipality generally has a high unemployment rate (Digby Wells Environmental, 2014). Gallant (2012) created a deprivation index to measure poverty of magisterial districts in South Africa, using dimensions such as education, household assets, facilities and access to services. The poverty index for Delmas magisterial district was 0.374 in 1996, 0.446 in 2001, and 0.286 in 2007 (with 1 being poor, and 0 being non-poor). The change in mean deprivation for Delmas was 0.072 for the period 1996-2001 (i.e. increase in poverty), and -0.146 for the period 2001-2007 (i.e. decrease in poverty).

A history of water-borne disease events exists for the Delmas region. A diarrhoea and typhoid outbreak occurred in 1993, with thousands of school children presenting at local doctors for treatment of diarrhoea (February 1993) due to problems with potable water, and towards the end of 1993, when the rains set in, a rapid onset outbreak of diarrhoea occurred, with more than 2000 cases with gastrointestinal disease (of which 57 were confirmed to have contracted typhoid fever). Two more epidemics of diarrhoea occurred in 2005 and 2007 respectively, highlighting problems that exist with Delmas's disaster management capability (NDMC, 2009). A wastewater treatment plant was commissioned in Delmas in 2011 to prevent similar recurrences.

Based on a 2014 scoping report for the Kangala Colliery (Digby Wells Environmental, 2014), of the 13 389 households in the Delmas Local Municipality 9 462 households (71%) have piped potable water on their stands that are also connected to a water-borne sanitation system, 62% live in formal housing and 65% use electricity for lighting. The medical infrastructure for the Delmas local municipality consists of a public hospital, three public health clinics, three mobile clinics and 14 non-governmental organisations that attend from HIV/AIDS counselling to home-based care. Private health services include a Medicross Health Centre, six medical doctors in private practice, two dentists, an optometrist, a dietician, a physiotherapist, and a psychologist.

The area around the Eloff Project has got a high agricultural potential. Land outside of areas being actively mined are used for irrigated crop production, dryland crop production, grazing and farming infrastructure. The rest of the land is used for mining and mining infrastructure. Areas not yet disturbed by mining activities have arable and grazing land capability. Some rehabilitated areas may already have wilderness land capability, but areas that are not sufficiently rehabilitated yet and active mining areas have industrial land capability (GCS, 2013).

The poverty index, vulnerability to water-borne diseases (in case the water supply system is damaged by climate change-related events such as flooding), populations that (1) still don't have access to piped potable water, (2) still live in informal housing, (3) still don't have access to electricity, and (4) may not have ready access to the medical infrastructure, contribute to the vulnerability and adaptive capacity of the community in the Project region with respect to climate change.

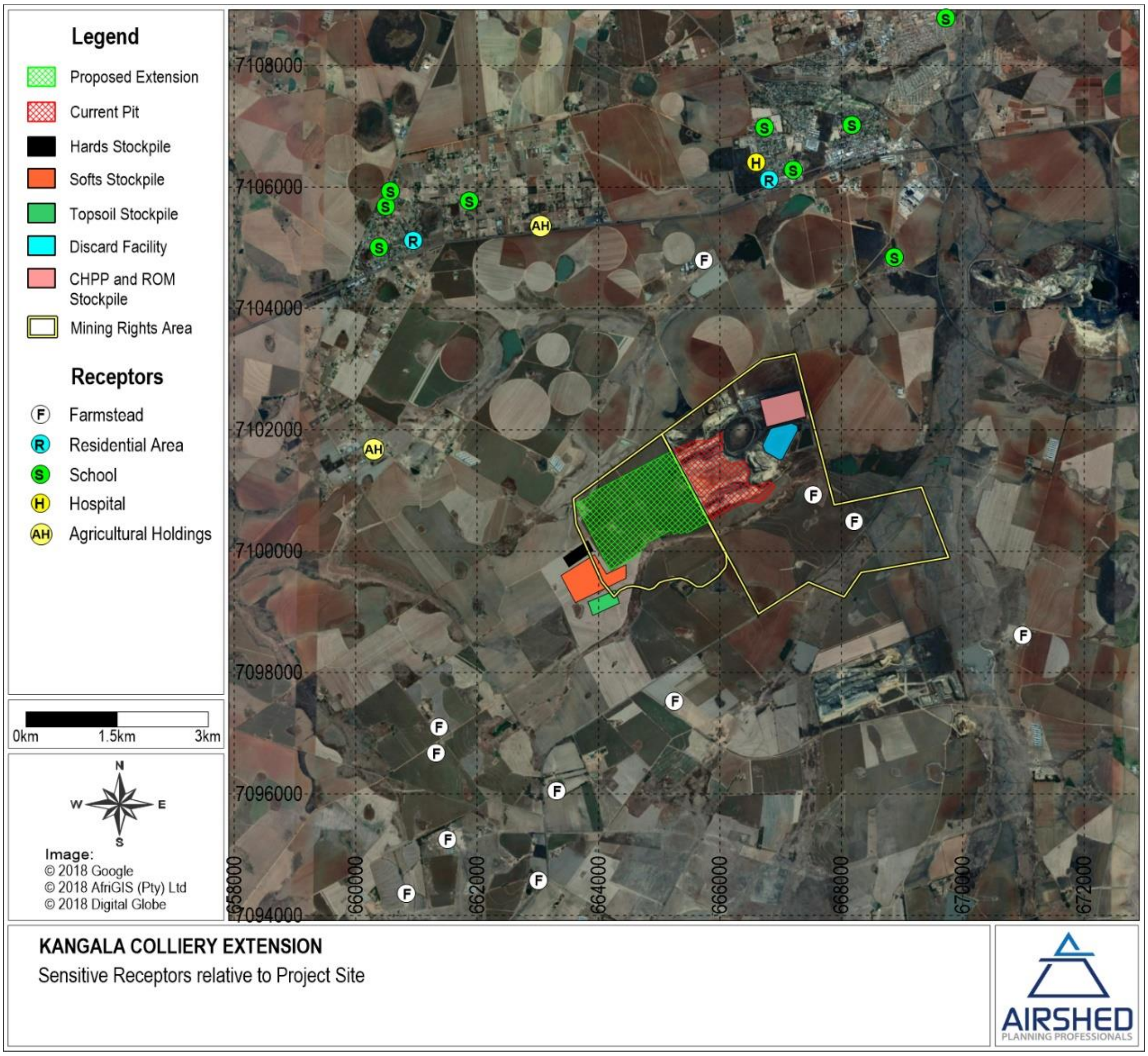

Figure 3: Location of sensitive receptors relative to the Project

3 CLIMATE CHANGE IMPACT ASSESSMENT

The project's carbon footprint, potential effect of climate change on the project and potential effect of climate change on the community are discussed in Sections 3.1, 3.2 and 3.3 respectively.

3.1 Project's Carbon Footprint

3.1.1 GHG Emissions

For the future Eloff Project operations scope 1 and scope 2 emissions are applicable (see Section 1.3.1.2.3 for explanation of Scope 1 and 2 emissions). Scope 1 emissions[4] were based on the annual vehicles' fuel use and scope 2[5] on the approximate electricity requirements.

3.1.1.1 Construction Phase and Decommissioning Phases

There is insufficient data at this point to determine the construction/ decommissioning phase Scope 1 and Scope 2 emissions.

3.1.1.2 Operational Phase

Scope 1 Emissions

The IPCC provides default emission factors for gasoline and diesoline in kg CO_2/unit energy content, while the density and calorific values are available from a number of standard engineering databases. Using the values in Table 2, the CO_2 emission factor can be calculated per litre of fuel used, which allows calculation of the total emissions directly from fuel records. The estimated amount of fuel (diesel) used per annum is 17 400 litres. The methane (CH_4) and nitrous oxide (N_2O) emission factors are given in Table 3 .

Table 2: Calculation of liquid fuel-related CO_2 emission factors (for vehicles)

Type of fuel	CO_2 emission factor kg/TJ	Density kg/m^3	Calorific value kJ/kg	Emission factor kg CO_2/litre fuel
Gasoline	69 300	720	44 400	2.215
Diesoline	74100	840	43 400	2.701

Table 3: Vehicles - liquid fuel-related methane and nitrous oxide emission factors

Type of fuel	Density kg/m^3	Emission factor g CH_4/gallon	Emission factor g N_2O/gallon
Diesoline	840	0.58	0.26

[4] Scope 1 emissions are defined as all direct GHG emissions, which include CO_2, CH_4 and N_2O releases due to fossil fuel combustion (diesel) as well as the release of CH_4 due to surface coal mining. The 2006 IPCC Guidelines have emission factors for methane releases from surface coal mining (IPCC, 2006). However, only the tonnage of coal mined per annum from surface mines is required to be reported on by the NGER Regulations of 2016, with the South Africa-specific default emission factor for CH_4 given as 0 (Department Environmental Affairs, 2014a).

[5] The South African mandatory reporting guidelines focus on the reporting of Scope 1 emissions only.

Scope 2 Emissions

These emissions are related to purchased energy, heat or steam and can be calculated from the average South African emission factor published annually by Eskom in its annual report (more recently its integrated sustainability report). The numbers for the most recently available four years are given in Table 4. This allows the scope 2 emissions to be calculated directly from electricity consumption from the Eskom or local authority account. The electricity usage per annum is 14.4 MWh (information provided by client).

Table 4: Eskom electricity emission factors

Year	Emission Factor kg CO_2/kWh	Source
2007/2008	1.00	Eskom 2009 Annual Report
2008/2009	1.03	Eskom 2009 Annual Report
2009/2010	1.03	Eskom 2010 Integrated Report
2010/2011	0.99	Eskom 2011 Integrated Report

Summary

A summary of the greenhouse gas emissions is provided in Table 5. For CH_4 and N_2O, the CO_2 equivalents were used, given as 25 times for CH_4 and 298 times for N_2O (http://www.climatechangeconnection.org/emissions/CO2_equivalents.htm). The total CO_2 (equivalent) emissions of approximately 62.07 tpa should be seen in the perspective of the annual South African emission rate of GHG, which is approximately 544.31 million metric tonnes CO_2-e. The calculated CO_2-e emissions from the future Eloff operations therefore contribute 0.00001% to the total of South Africa's GHG emissions, 0.0001% of the total "manufacturing industry and construction" sector and 0.003% of the "manufacturing industry and construction" sector's emission due to liquid fuel use. As indicated in Section 1.3.1.2.4.1, GHGs were declared priority pollutants in March 2014 and pollution prevention plans must be developed if the operation contributes more than 100 000 tons CO_{2eq} emissions. The scope 1 GHG contribution is below 100 000 tons. Based on this, a Pollution Prevention Plan is not required for the future Eloff Project operations.

Table 5: Summary of estimated greenhouse gas emissions for the future operations

Source Group	CO_2	CH_4 as CO_2-e	N_2O as CO_2-e	CO_2
	tpa	tpa	tpa	%
Vehicle Exhaust (Scope 1)	47	0.07	0.36	76%
Electricity (Scope 2)	14.58	0.01	0.06	24%
Total	**61.58**	**0.07**	**0.42**	**100%**

3.1.2 Carbon Tax

The Draft Carbon Tax Bill (Minister of Finance, 2017) provides an equation for the calculation of carbon tax:

$$X = \{(E - D - S) \times (1 - C) \times R\} + \{P \times (1 - J) \times R\} + \{F \times (1 - K) \times R\}$$

Where:

- "X" represents the amount to be determined;

- "E" represents the number in respect of the total fossil fuel combustion related greenhouse gas emissions of the taxpayer in respect of that tax period expressed as a carbon dioxide equivalent;
- "D" represents the number in respect of the petrol and diesel related greenhouse gas emissions of that taxpayer in respect of that tax period expressed as a carbon dioxide equivalent;
- "S" represents the number in respect of greenhouse gas emissions, expressed in terms of carbon dioxide equivalent that were sequestrated in respect of that tax period as verified and certified by the Department of Environmental Affairs;
- "C" represents the sum of percentages of allowances;
- "R" represents the rate of tax prescribed;
- "P" represents the number in respect of the total industrial process and product use related greenhouse gas emissions of the taxpayer in respect of that tax period expressed as a carbon dioxide equivalent;
- "J" represents the sum of the percentages of the allowances;
- "F" represents the number in respect of the total fugitive greenhouse gas emissions of the taxpayer in respect of that tax period expressed as a carbon dioxide equivalent; and
- "K" represents the sum of the percentages of the allowances

The rate of the carbon tax on GHG emissions must be an amount of R120 per ton CO_2eq of GHG emissions of a taxpayer.

For opencast coal mining activities, the calculation of carbon tax can be expressed as follows since the fugitive and industrial process related greenhouse gas emissions are zero:

$$X = \{(E - D - S) \times (1 - C) \times R\}$$

As all fossil fuel combustion GHG quantified are diesel related, the equivalent carbon tax is zero.

3.1.3 The Project's GHG Impact

3.1.3.1 Magnitude

The GHG emissions from the project are low and will not likely result in a noteworthy contribution to climate change on its own.

3.1.3.2 Impact on the sector

The GHG emissions from the project form 0.0001% of the "manufacturing industry and construction" sector's total annual CO_2-e emissions and will therefore not make a significant contribution towards the sector's GHG impact.

3.1.3.3 Impact on the National Inventory

The GHG emissions from the project form 0.00001% of the national inventory's total annual CO_2-e emissions, which is negligibly low.

3.1.3.4 Alignment with national policy

As from the next NAEIS reporting period UCD1 will have to start reporting on GHG emissions.

3.2 Impact Assessment: Potential Effect of Climate Change on the Project

The most significant of the discussed climate change impacts on the project would be as a result of:

- Temperature increase,
- Possible reduction in rainfall.

The seasonal plan tool was used to assess the impact of higher temperatures and lower rainfall on the Delmas region, and specifically the impact that climate change may have on the Eloff project (Figure 4).

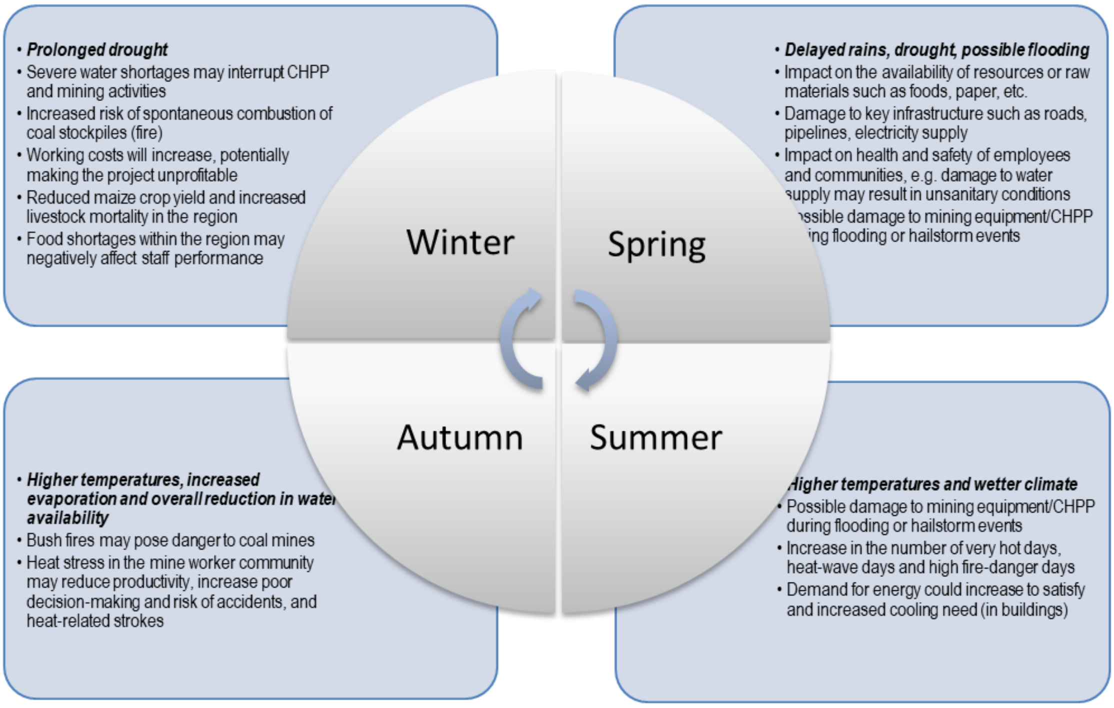

Figure 4: Seasonal plan tool to assess impact of changing climatic conditions on the project (adapted for the Eloff Project from Keränen *et al.*, 2012).

3.3 Impact Assessment: Potential Effect of Climate Change on the Community

With the increase in temperature there is the likelihood of an increase in discomfort and possibility of heat related illness (such as heat exhaustion, heat cramps, and heat stroke). There is also the possibility of increased evaporation which in conjunction with the decrease in rainfall can result in water shortage. This does not only negatively affect the community's water supply but can reduce the crop yields and affect livestock (agriculture) resulting in a food security issue.

3.3.1 Regional Profile

The profile of the community is described under Section 2.2.

3.3.2 Vulnerability

Delmas Region has an adaptive capacity of approximately 45%, based on indicators such as poverty, literacy, HIV prevalence, prevalence of malnutrition among children <5, access to facilities and access to services. The vulnerability of rural households to climate change in the Delmas Region is deemed to be Moderate to High. The vulnerability of the mainly farming communities surrounding the study region is described in a diagram in Figure 5.

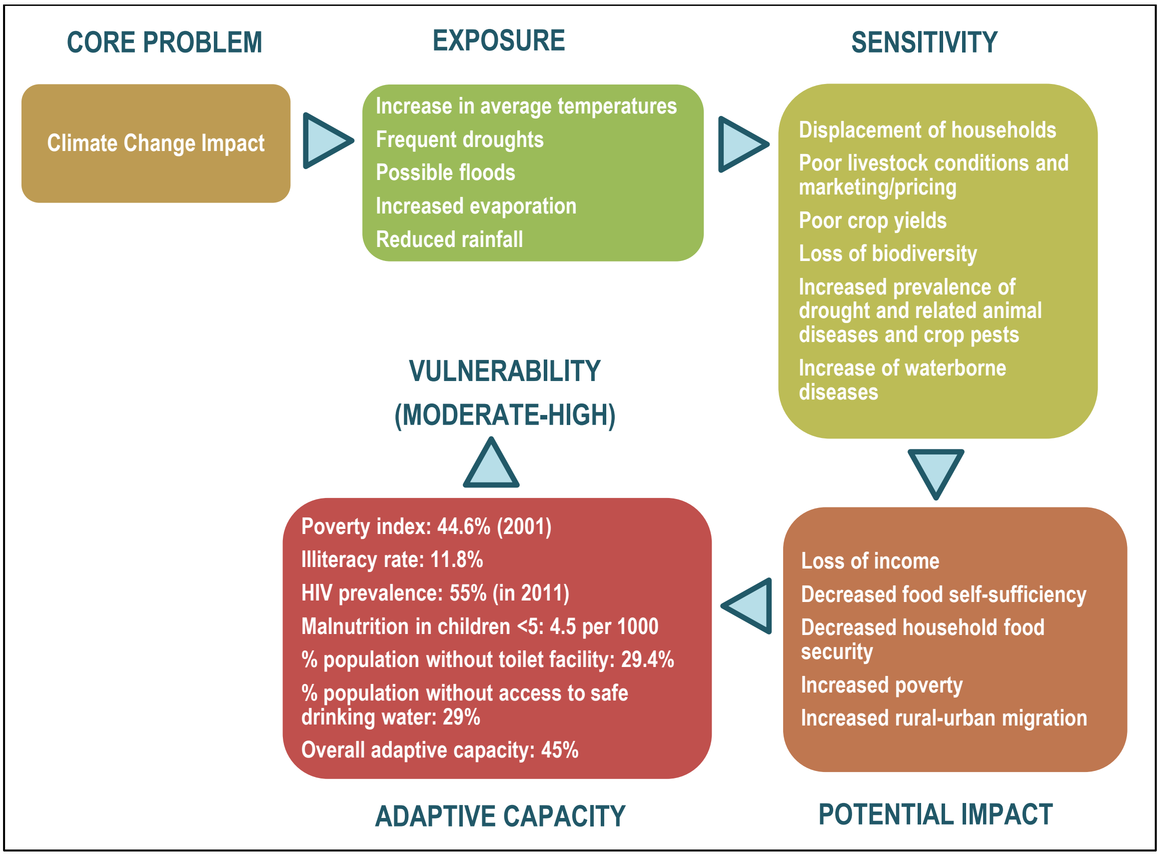

Figure 5: Vulnerability of rural households in the Delmas region to climate change (Adapted for the Delmas region from: University of Namibia, 2008)

3.4 Adaptation and Management Measures

Climate change management includes both mitigation and adaptation. The main aim of mitigation is to stabilise or reduce GHG concentrations as a result of anthropogenic activities. This is achievable by lessening sources (emissions) and/or enhancing sinks through human intervention.

3.4.1 Project adaptation and mitigation measures

3.4.1.1 General

Additional support infrastructure can reduce the climate change impact on the staff and project, for example the addition/upgrading of an on-site clinic, ensuring adequate water supply for staff and reducing on-site water usage as much as possible. UCD1 could initiate a community development program if one is not already in place.

3.4.1.2 Scope 1 (technology/sector-specific)

One way to keep GHG emissions to a minimum would be to ensure there is minimal fuel use, this can be achieved by ensuring the vehicles and equipment is maintained through an effective inspection and maintenance program. A measure of reducing the project's impact is to limit the removal of vegetation and to ensure that that as much as possible revegetation occurs and possibly even the addition of vegetation to the surrounding project area.

3.4.1.3 Scope 2

All Scope 2 emissions are the consequence of electricity use. In terms of total magnitude, these emissions have a relatively low impact on the total GHG emissions as the mining process is energy intensive and relies on diesel powered machines or processes. It has also been observed that the contribution of office energy consumption is relatively modest (2% - 7%) compared with electricity consumption by equipment by mining and coal handling facilities (93% - 98%) (Pandey and Gautam, 2017). By identifying significant energy-consuming equipment it may be possible to recognise opportunities where technical efficiencies in plant and equipment can be applied.

4 CONCLUSIONS

A climate change impact study was conducted for the proposed opencast Kangala Colliery Extension (Eloff Project), which will be the life extension of Kangala from 2020 when the coal reserves at Kangala are depleted. Airshed was appointed to calculate the carbon footprint and determine the GHG emissions arising from the operations of the Eloff Project. The requirement is in preparation for the proposed carbon taxation which is likely to take effect as of next year, and to comply with the NGER which requires all coal mines to account for the amounts of pollutants discharged into the atmosphere (total emissions for one or more specific GHG pollutants) by 31 March each year.

The main findings are:

- The total CO_2-e emission for the Eloff project operations is approximately 62 tpa, of which 76% is due to vehicle exhaust emissions and 24% is due to electricity consumption.
- The GHG emissions from the project are **low** and will not likely result in a noteworthy contribution to climate change on its own.
- The project and the community are likely to be negatively impacted by climate change, the project less so than the community, firstly due to the short time over which operations are planned to occur, and secondly because the project has measures in place to cope with the possibility of water shortage (likely to be the most significant problem faced) due to the up-sizing of the CHPP.
- The project and the community are likely to be negatively impacted by climate change due to increased temperatures and possible water shortages (decreased rainfall and possible increased evaporation). The community is estimated to have a moderate to high vulnerability to climate change, based on poverty, literacy, HIV prevalence, prevalence of malnutrition among children aged less than 5, access to facilities and access to services.

4.1 Recommendations

- The following is recommended to reduce the GHG emissions from project:
  - Ensuring the vehicles and equipment are maintained through an effective inspection and maintenance program.
  - Limiting the removal or vegetation and ensuring adequate re-vegetation or addition of vegetation surrounding the project. Vegetation acts as a carbon sink.
- The following is recommended to reduce the impacts of climate change on the project and the community:
  - Additional support infrastructure can reduce the climate change impact on the staff and project, for example the addition/upgrading of an on-site clinic, ensuring adequate water supply for staff and reducing on-site water usage as much as possible.
  - UCD1 could initiate a community development program if one is not already in place.

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6 APPENDIX A – SPECIALIST CURRICULUM VITAE

CURRICULUM VITAE

Name	Rochelle Bornman
Date of Birth	24 August 1974
Nationality	South African
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Air Quality Specialist
Profession	Scientist
Years with Firm	10

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Member of National Association for Clean Air (NACA)

EXPERIENCE

- Emissions inventory compilation
- Meteorological, topographical and land use data processing and preparation
- Dispersion modelling experienced in SCREEN, AERMOD, ADMS, CALINE and CALPUFF dispersion models.
- Impact and compliance assessment
- Air quality and dust management plan preparation
- Atmospheric emission license application
- Industry sectors in which experience have been gained with specific reference to air quality include:
    - Opencast and underground mining of: copper, platinum, gold, iron, and coal.
    - Production of: copper, platinum, gold, base metals, iron, steel, and tyre pyrolysis.
    - Biomass to Energy production
    - Fire behaviour modelling

SOFTWARE PROFICIENCY

- Atmospheric Dispersion Models: AERMOD, ISC, CALPUFF, ADMS (United Kingdom), TANKS
- Other: Golden Software Surfer, Lakes Environmental WRPlot, MS Word, MS Excel, MS PowerPoint, ArcMap, ArcView

EDUCATION

- B. Land Surveying: 1997, *University of Pretoria*
- MPhil: (Geographical Information Systems and Remote Sensing) 1998, *University of Cambridge*

COURSES COMPLETED AND CONFERENCES ATTENDED

- NACA Conference 2010, 2011
- Laboratory Systems Course (ISO 17025: 2017) March 2018

COURSES PRESENTED

- Geodesy and Land Surveying at the University of Pretoria (1999)

COUNTRIES OF WORK EXPERIENCE

- South Africa, Namibia, Mozambique, Saudi Arabia, Mali

LANGUAGES

Language	Proficiency
English	Full professional proficiency
Afrikaans	Full professional proficiency

REFERENCES

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Dr. Hanlie Liebenberg Enslin	Managing Director at Airshed Planning Professionals	+27 (83) 416 1955 hanlie@airshed.co.za

CERTIFICATION

I, the undersigned, certify that to the best of my knowledge and belief, these data correctly describe me, my qualifications and my experience.

7 APPENDIX B – EFFECTS OF CLIMATE CHANGE ON THE REGION

7.1 Climate Change Reference Atlas

In 2017 the SAWS published an updated Climate Change Reference Atlas (CCRA) based on Global Climate Change Models (GCMs) projections. It must be noted that as with all atmospheric models there is the possibility of inaccuracies in the results as a result of the model's physics and accuracy of input data; for this reason, an ensemble of models' projections is used to determine the potential change in near-surface temperatures and rainfall depicted in the CCRA. The projections are for to 30-year periods described as the near future (2036 to 2065) and the far future (2066 to 2095). Projected changes are defined relative to a historical 30-year period (1976 to 2005). The Rossby Centre regional model (RCA4) was used in the predictions for the CCRA which included the input of nine GCMs results. The RCA4 model was used to improve the spatial resolution to 0.44° x 0.44°- the finest resolution GCMs in the ensemble were run at resolutions of 1.4° x 1.4° and 1.8° x 1.2°.

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

7.1.1.1 RCP4.5 trajectory

Based on the median temperature change and the region in which the Eloff Project and AQSRs are situated, the annual median near surface temperatures (2 m above ground) are expected to increase by between 1.5°C and 2°C for the near future and between 2.5°C and 3°C for the far future. The seasonal average temperatures are expected to increase for all seasons. The total annual rainfall is expected to increase by between 10 and 20mm in the near future and decrease by between 0 mm and 10 mm for the far future. For the near future the total seasonal rainfall is expected to increase in summer, and decrease between 0 and 10mm for the rest of the year.

7.1.1.2 RCP8.5 trajectory

Based on the median, the region in which the Eloff Project and AQSRs discussed are situated, the annual average near surface temperatures (2 m above ground) are expected to increase by between 2.5°C and 3°C for the near future and between 4.5°C and 5°C for the far future. The seasonal average temperatures are expected to increase for all seasons. The total annual rainfall is expected to increase by between 5 mm and 10 mm for the near future and decrease by between 0 and 10 mm for the far future. For the near future the total seasonal rainfall is expected to increase for summer and decrease for autumn, winter and spring. The total seasonal rainfall is expected to decrease for autumn and winter for the far future. Spring rainfall is expected to decrease more drastically for the far future. Summer rainfall is expected to increase for the far future, to a larger degree than for the RCP4.5 trajectory.