Assessing whether rehabilitation programmes from South African mining companies have considered the impacts of climate change.

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MSc Interdisciplinary Global Change Studies

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A Research Report submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science.

May 2016
Declaration

I declare that this Research Report is my own, unaided work. It is being submitted for the Degree of Master of Science at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

(Signature of candidate)

7th day of MAY 2016 at the University of the Witwatersrand
Abstract

The fifth report by the Intergovernmental Panel on Climate Change (IPCC) has a high confidence level that positive radiative forcing due to anthropogenic influences are causing a warming earth surface, and the largest contributor is CO₂. Previous research related to mining and climate change, has been inclined to the development of mitigation measures, further addressing how best the mining sector could reduce greenhouse gas emissions which adversely affect the climate system. Minimal research has focused on adaptation measures. The climate - both present and future - is seen as the most vital determinant of rehabilitation success or failure, specifically rainfall patterns and the temperature. Planning for rehabilitation while taking into account climate change, is the first step to enhancing adaptation, allowing successful and resilient rehabilitation.

This study aimed to assess whether mining companies operating in South Africa have considered the impacts of climate change on mine rehabilitation. The study achieved this with the use of a qualitative research methodology which included detailed content analysis of documents and transcripts from interviews conducted. From graphical representations of likely future scenarios of climate change, it was identified that all mining companies will be exposed to climate change, thus increasing their vulnerability to future impacts. Secondly, it was identified that only three of the investigated policies and guidelines on closure make a specific mention to climate during the rehabilitation process (MMSD, ITRC and CoM). Through the analysis of Sustainability Reports, it became apparent that climate change issues are prioritised in the selected companies; however, these predominantly transpire as mitigation measures (i.e. energy consumption, GHG emissions and water availability) in response to legal requirements already instituted as well as forthcoming legal frameworks. Only two of the investigated companies have considered climate change during the rehabilitation process of the mine lifecycle. Additionally, the interview process revealed further that climate change is being considered, during the operational phase of the mine lifecycle and the responses are mitigation measures to comply with the legal frameworks. Lastly, from the identified case studies which show how physical climate change impacts can be addressed, an identified trend showed informed decision making by interdisciplinary individuals using credible regional data
contributed to some successes. A total of six challenges were identified where after these were seen as strategic components to further catalyse adaptation planning in mine rehabilitation (data sources and management systems, legal framework, collaborations, research and development, funding and sustainability leadership). The findings of this research have created a foundation on which other research, addressing climate change within the South African mining industry, can progress which may further explore the mining company perspective or alternatively the government perspective which was not dealt with thoroughly in this study.

**Key words:** Adaptation, Climate change, Mine rehabilitation, Mitigation, Sustainable development
This research is dedicated to my parents, Duduzile and Mziwandile Ndlovu and my grandmother, Sikana Zondi.

Thank you for making education invaluable.
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As part of the first MSc Interdisciplinary Global Change Studies class, I am privileged to have been part of such great conversations and knowledge exchange. The content in lectures during this degree was invaluable. I hope I am able to carry this enthusiasm further in my career.

Finally, two quotes that were an earworm for the entire Masters year:

“Be the change you want to see in the world” ~ Mahatma Gandhi

“We cannot solve our problems with the same thinking we used when we created them” ~ Albert Einstein
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<td>Acid mine drainage</td>
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<tr>
<td>ARC</td>
<td>Agricultural Research Council</td>
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<tr>
<td>ARD</td>
<td>Acid rock drainage</td>
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<tr>
<td>BSI</td>
<td>British Standards Institute</td>
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<tr>
<td>CCS</td>
<td>Carbon capture and storage</td>
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<td>CDP</td>
<td>Carbon Disclosure Project</td>
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<tr>
<td>CSI</td>
<td>Corporate Social Investment</td>
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<tr>
<td>CSIR</td>
<td>Council for Scientific and Industrial Research</td>
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<td>CoM</td>
<td>Chamber of Mines</td>
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<tr>
<td>COO</td>
<td>Chief Operating Officer</td>
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<tr>
<td>DEA</td>
<td>Department of Environmental Affairs</td>
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<tr>
<td>DERO</td>
<td>Desired Emissions Reduction Outcomes</td>
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<tr>
<td>DME</td>
<td>Department of Minerals and Energy</td>
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<tr>
<td>DST</td>
<td>Department of Science and Technology</td>
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<td>EITI</td>
<td>Extractive Industries Transparency Initiative</td>
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<td>EMPR</td>
<td>Environmental Management Programme Report</td>
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<td>EMS</td>
<td>Environmental Management System</td>
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<td>ENSO</td>
<td>El-Niño Southern Oscillation</td>
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<td>GCM</td>
<td>Global Climate Model</td>
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<td>GHE</td>
<td>Greenhouse effect</td>
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<td>GHGs</td>
<td>Greenhouse gases</td>
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<td>GMI</td>
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<td>ICMM</td>
<td>International Council on Mining and Metals</td>
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<td>IIED</td>
<td>International Institute for Environment and Development</td>
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<td>ITRC</td>
<td>Interstate Technology and Regulatory Council</td>
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<td>IUCN</td>
<td>International Union for Conservation of Nature</td>
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<td>JSE</td>
<td>Johannesburg Stock Exchange</td>
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<td>LTAS</td>
<td>Long-Term Adaptation Scenarios</td>
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<td>LTMS</td>
<td>Long-Term Mitigation Scenarios</td>
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<td>MMSD</td>
<td>Mining, Minerals and Sustainable Development</td>
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<td>Acronym</td>
<td>Full Form</td>
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<td>MPRDA</td>
<td>Mineral and Petroleum Resources Development Act</td>
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<td>NBI</td>
<td>National Business Initiative</td>
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<td>National Development Plan</td>
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<td>National Climate Change Response Policy</td>
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<td>South African Environmental Observation Network</td>
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<td>SD Reports</td>
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<td>SREX</td>
<td>Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation</td>
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<td>UN</td>
<td>United Nations</td>
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<td>United Nations Environmental Programme</td>
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<td>UNGC</td>
<td>United Nations Global Compact</td>
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<td>WAP</td>
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Chapter 1

1 Introduction

1.1 Research context

Climate change adaptation and mitigation

The Fourth Assessment Report (AR4) produced by the Intergovernmental Panel on Climate Change (IPCC) was the first of the reports to state that “warming of the climate system is unequivocal with warming being caused by increasing greenhouse gas (GHG) concentrations associated with human activity” (Weinhofer and Busch, 2013). Since then, the Fifth Assessment Report (AR5) has reiterated these findings and further stated that the mining sector is one of the sectors that are vulnerable to climate change (IPCC, 2014a). Little research has been dedicated to assessing how mine rehabilitation projects will be affected by climate change (NRCan, 2007; Pearce et al., 2011). Some research has focused on how physical climate change impacts affect the operational phase of the mine lifecycle, since future adaptation to climate change is perceived to have high implementation costs (Pearce et al., 2011). Damigos (2012) lists numerous factors that will affect the economic viability of the mining sector; among these are increased dry days as well as water unavailability, which will both affect rehabilitation. Furthermore, research undertaken by Lemmen et al. (2008), Seguin (2008), Nelson and Schuchard (2009), Pearce et al. (2011), Damigos (2012) and the International Council on Mining and Minerals (ICMM) in ICMM (2013), explains how the mining sector has focused on climate change mitigation with the aim to either improve the public image, implement management systems or improve preparedness towards forthcoming climate change legislation. The mining sector experiences difficulties when it comes to understanding the physical impacts of climate change and therefore adaptation planning becomes a complex task (Pearce et al., 2011; Damigos, 2012). However, this is not only true for the mining sector as has been shown by Tol (2007), Basher (1999), Harrison et al. (2010) and McEvoy et al. (2010). The few mining companies that have started taking adaptation actions face the challenges of cost quantification and high levels of uncertainty (Ford et al. 2010; Pearce et al. 2011; Damigos, 2012). Notwithstanding these challenges, many agree that a focus
on adaptation planning (especially during rehabilitation) is important for the long term sustainability of the mining sector (Harrison et al., 2010; and Pearce et al., 2011; Damigos, 2012).

Climate change mitigation measures are described as activities and innovations that assist in lowering the concentration of GHGs in the atmosphere or alternatively developing storage capacities of GHGs (IPCC, 2014). Such efforts, as described by the United Nations Convention on Climate change (UNFCCC), are designed to prevent anthropogenic climate change and further allow the natural environment to be able to adapt, while also ensuring that business develops sustainably and enhances economic development (IPCC, 2014). Furthermore, the Intergovernmental Panel on Climate Change (IPCC) has highlighted how effective climate change mitigation can only be achieved through the collaboration of private and public as well as individual and communal efforts (IPCC, 2014). With such associations, it is highlighted that skills development will ensue as knowledge transfer occurs while also developing regions economically (IPCC, 2014). In the South African context, the government has motivated the development of a mix of mitigation measures that are tailored for each sector (NCCRP, 2011). These include the use of market instruments as well as the inclusion of monitoring and evaluation strategies (NCCRP, 2011).

Climate change adaptation measures assist in developing resilience through addressing the impacts that are most likely to pose a threat to a particular sector and further assist in coping with the impact (Midgley et al., 2007). Adaptation can be achieved through the development of technologies and policies that address the impacts, additionally supported by research highlighting how to best encourage resilience (IPCC, 2014a). Furthermore, adaptation is not only aimed at avoiding harm, it may additionally present beneficial opportunities from responding positively to the impacts (IPCC, 2014a). Adaptation responses can be integrated into existing planning tools and processes (Midgley et al., 2007; IPCC, 2014a). According to the South African government, adaptation measures are better equipped to respond to climate change as such measures can be easily implemented at a local level as opposed to mitigation measures (NCCRP, 2011; Milner and Dietz, 2015). As a plan of action, Ziervogel et al. (2014) call for climate change to not be considered as a mere environmental problem but as also a developmental problem where adaptation measures can be seen as developmental tools.
An environment that harnesses and encourages adaptation is one where cross sectoral collaborations are taken in addition to knowledge sharing centres which play a pivotal role in developments (Lesnikowski, 2013). However, adaptation, when compared to mitigation, is a relatively recent field in the climate debate and thus more research is still being undertaken and required (Klein et al., 2007; McEvoy et al., 2010). It has also been shown that adaptation, as a consequence of still being a developing area in climate change, the extent, feasibility, efficiency and cost effectiveness of many initiatives remains unknown (McEvoy et al., 2010).

**Rehabilitation and the mine lifecycle**

Governments require that land that has been disturbed by mining activities is either returned to its pre-mining land use state or alternatively be turned to a land use that is aligned with the principles of sustainable development (CoM and CoalTech, 2007). Therefore, to achieve this goal, it necessitates that mining companies approach closure in a holistic manner to further ensure that this mandate is fulfilled. The ICMM has emphasised that closure planning should take place at the very initial stages of the project. By ensuring that the mine is planned with closure in mind, it necessitates that mine rehabilitation is well accounted for and further reduces the liability once the operations have ceased (ICMM, 2008). A conceptual planning process is recommended as soon as exploration commences, where after detailed closure planning is pursued during the operational stage of the mine lifecycle (ICMM, 2008). The product of this approach to closure is the reduction of risks (ICMM, 2008). Although closure planning ideally takes place throughout the mine lifecycle, it is also good practice to undertake rehabilitation trials, concurrent rehabilitation efforts as well as other financial estimations in conjunction with the process of conceptual and detailed closure planning (ICMM, 2008). It is vital that all these endeavours are followed through to prevent financial implications in future as well as consider the public’s wellbeing by minimising possible contamination events.

As part of rehabilitation, many environmental characteristics determine whether the programme implemented is successful, especially in achieving ecosystem functionality. The report by the Commonwealth of Australia (2006) defines three aspects that encompass rehabilitation which are; firstly to build up landforms and appropriate land uses for an area that has been mined, secondly to
ensure that the development’s characteristics and changes are predictable and are also in line with the principles established initially, and thirdly that the area establishes and maintains a sustainable ecosystem. A noteworthy point is that not all rehabilitation efforts are aimed at returning the disturbed land to its previous land use; however, any land use that is synonymous to sustainable development principles is acceptable (CoM and CoalTech, 2007).

The report by the Commonwealth of Australia has also listed key physical constraints that apply to rehabilitation. The constraints are climatic conditions, the size of the area to be rehabilitated as well as the soil and rock characteristics (Commonwealth of Australia, 2006). Above all, the climate - both present and future - is seen as the most vital component that determines rehabilitation success or failure, more especially rainfall patterns and the temperature (Commonwealth of Australia, 2006; ITRC, 2009; Nordstrom, 2009). The aforementioned climatic conditions further affect the substrate’s potential of erodibility, chemical characteristics (acidity, salinity, sodicity etc.), nutrient availability, drainage capacity as well as other biological constituents (microbial activity, rooting depth etc.) (ITRC, 2009; Nordstrom, 2009). It has been reiterated that climate considerations need be made in identifying realistic rehabilitation targets, in plant species selection, in achieving land stability, in cover system design as well as in soil profile developments (Commonwealth of Australia, 2006; CoM and CoalTech, 2007; ITRC, 2009; Nordstrom, 2009).

**Sustainable development**

The term “sustainable” in recent years, has been high on the global agenda and has increasingly taken centre stage in negotiations and dialogues across all industries and spheres of society. Due to the nature of the different sectors, the definition of this adjective has received varying meanings depending on the businesses core operations. The United Nations’ (UN) World Commission on Environment and Development (WCED) in 1987 defined sustainable development as “…meeting the needs of the present without compromising the ability of future generations to meet their own needs.” (UN, 1987). To further understand the sustainability concept, there needs to be an investigation of the values and principles that foster sustainability and thus assist in decision making.
The British Standards Institute (BSI) has compiled a set of principles that are recommended for organisations to promote sustainability (Figure 1.1). In being inclusive, this takes into consideration the views expressed by stakeholders, how stakeholders are affected by decisions and further necessitates the consideration of parties beyond the stakeholder sphere. Integrity addresses the exclusion of dishonest behaviours such as bribery, corruption and oppression, additionally ensuring that all legal obligations and regulations are fulfilled. Transparency speaks to the accessibility of information through various low-cost media and also facilitating gatherings for all affected parties. Finally is stewardship which addresses how the organisation will impact on the society as well as the environment, while also ensuring that skills development occurs.

![Principles fostering sustainable development, adapted from BSI (2006).](image)

**Figure 1.1: Principles fostering sustainable development, adapted from BSI (2006).**

Sustainable development considers the holistic approach to meeting the needs of all individuals while also considering the future demands (Xu *et al.*, 2006). Sustainability thus proposes a mechanism that looks at the availability of natural resources and reserves for exploitation while not adversely affecting the environment (Goodland and Ledec, 1987; Xu *et al.*, 2006). The problem then comes in the quantification of natural resources as monetary values. Sustainable development thus aims to foster interdependence on such characteristics additionally identifying the intrinsic value of
the environment conversely to how it is perceived in conventional economics (Goodland and Ledec, 1987; Cato, 2009).

The sustainability approach has evolved significantly starting from the Triple Bottom Line (TBL, still commonly used), to the Natural Step and more recently the Five Capitals Framework (Porritt, 2007). The latest of the models; however, provides the most holistic view of sustainability through the lens of the capitalist system, hence the framework being named the Five Capitals (Figure 1.2). This model is based on interlinking the capitals (stocks) that facilitate the functioning of organisms and organisations across the globe (Porritt, 2007). These stocks are categorised as the Natural, Human, Social, Manufactured and Financial Capitals (Forum for the Future, 2000; Porritt, 2007). As can be seen from this model (Figure 1.2), a balanced system needs to always be maintained both within and among the capitals through the flows of exchange (double sided arrows).

![Five capitals model of sustainability as presented in Porritt (2007).](image)

What has transpired frequently within the mining industry, or any other industry who’s nature of business is to exploit the natural environment, is that the natural capital is continuously reduced in exchange of social, human and manufactured capitals and most commonly the financial capital. Consequently this results in an unstable system prone to imbalances further defeating the aims of sustainable development. Thus the sustainable development framework, when highly regarded in the business environment, is likely to result in a balanced capital system.
1.2 Problem statement

Research problem

To fully understand whether mining companies operating in South Africa have approached mine rehabilitation planning from a climate change adaptation perspective, further ensuring that sustainable development principles are achieved; there needs to be an overarching enquiry of whether rehabilitation has thoroughly considered climate change impacts and further developed adaptation strategies in response. What has transpired is that mining companies have been continuously inclined to disclose and enforce more often on how they are contributing to climate change and consequently what efforts they are employing to mitigate climate change. However, other discussions suggest that companies need to place significantly more efforts in adaptation measures. Such an exercise will assist in identifying imminent risks to the business; which in this current study has been focused on the rehabilitation phase of the mine lifecycle. Upon risk identification and quantification, companies may be positioned to adopt mitigation measures which include investigating hospitable environmental conditions allowing successful rehabilitation as well as identifying the optimal measures to enhance rehabilitation in a changing climate.

1.3 Rationale and aim of the study

Policy development forms one of the crucial spheres in adaption, mitigation and risk management towards the negative effects of climate change (Agrawala, 2004). Therefore if the risks of climate change are considered during the planning of rehabilitation projects, the appropriate measures will be in place such as financial provision for the considered impacts (Vincent et al., 2008). This can be generated by explicitly measuring the effects of climate change on the baseline when environmental assessments are carried out as well as also identifying which impacts are probable (Larsen and Kørnøv, 2009). When this information has been obtained, other adaptation mechanisms can be put in place to further establish resilience in rehabilitation plans that are to be implemented, as highlighted in a study by Larsen and Kørnøv (2009) as well as the Commonwealth of Australia (2006); that suggests climate change effects should be considered in mitigation, adaptation and also in baseline adaptation.
Many case studies have documented how climate change will impact the exploration, operational and closure phases of the mining lifecycle. Very few studies have given much consideration of the post closure impacts of climate change especially in rehabilitation, as this will effectively determine the success of rehabilitation, holistically affecting the business risk and thus raising concerns about the sustainability of the business. Furthermore, South African legislative requirements and numerous other international guidelines, have reiterated the responsibility that should be taken by mining companies to ensure that rehabilitation post closure is effective and should be done so to perpetuity where possible contamination mobility could occur. Not only the Commonwealth of Australia, but also the Interstate Technology and Regulatory Council (ITRC), the ICMM as well as the Natural Resources Canada (NRCan) organisation have all highlighted how appropriate species selection and entire landscape planning is important in changing weather conditions as effective rehabilitation is dependent on such (Commonwealth of Australia, 2006; ITRC, 2009; ICMM, 2013). The main emphasis is to design a resilient ecosystem that is able to sustain itself in the long term and is also resilient to climate change (NRCan, 2007).

In addition to the mining industry taking responsibility for mine rehabilitation, projections of the future climatic system of the globe have been investigated and it has been declared beyond reasonable doubt that climate change is occurring. A major point that needs to be taken into account is that projections predict a shift in current vegetation dynamics. Additionally, according to the Mineral and Petroleum Resources Development Act (MPRDA, section 38 (1)(d)) a right holder has the responsibility to remedy the area and more specifically, “must as far as it is reasonably practicable, rehabilitate the environment affected by the prospecting or mining operations to its natural or predetermined state or to a land use which conforms to the generally accepted principle of sustainable development…”. The aim of the study is to investigate whether mining companies that are operating in South Africa have given climate change impacts a considerable thought at the post closure stage, especially in rehabilitation planning and implementation.

In order to address the aim of the study, several objectives have been identified to further enlighten on the topic. The objectives of the study are as follows:
Display the general predicted environmental changes associated with the impacts of climate change in South African provinces where mining activities are currently being pursued,

Review local and international guidelines on post closure practices,

Investigate whether mining companies operating in South Africa have considered the impacts of climate change, especially post closure,

Review case studies of mining companies that have considered climate change at the post closure stage especially in their rehabilitation planning.

The research questions of the study are:

(i) From the geographical orientation, will mining companies in South Africa be affected by climate change impacts?
(ii) What do local and international guidelines on post closure practices state about climate change considerations?
(iii) Have South African operating mining companies considered the impacts of climate change during rehabilitation?
(iv) How has climate change been considered in mining companies based internationally and locally?

1.4 Definition of terms

Climate change: The predicted deviation of the climate from the mean, which occurs over long periods, characteristically in decades or longer.

Climate variability: Contributes to climate change; however, variability ranges in short to long time frames. E.g. the El-Niño Southern Oscillation (ENSO) which is due to the coupled oceanic and atmospheric component, inter-hemisphere exchange as well as troposphere-stratosphere which are atmospheric components and lastly large ice sheet movement which are within the oceanic component.

Sustainable development: Considers the holistic approach to meeting the needs of all individuals while also considering the future demands through the view of the Five Capitals Model.

Rehabilitation: Aims to restore the ecosystem structure and functioning of a landscape; however, the historic vegetation type is replaced with species that are also able to retain the functionality of the ecosystem.
Restoration: Aims to repair a landscape to its naturally historic vegetation type to maintain the structure and functioning of the ecosystem further conserving biodiversity and indigenous species.

Mitigation: Activities and innovations that assist in lowering the concentration of GHGs in the atmosphere or alternatively developing storage capacities for GHGs.

Adaptation: Activities that assist in developing resilience through addressing the impacts that are most likely to pose a threat to a particular sector and further assist in coping with the impact.

Upside risk: A situation or an element that is prone to being a hazard but potentially has the capacity to result in a gain.

Downside risks: A situation or element that is prone to being a hazard and thus has a potential to result in losses.

1.5 Structure of the report

Chapter 1: This chapter introduces the study by placing it in a context and also presents the rationale of the study is leading on to the aims and objectives of the study.

Chapter 2: This chapter is aimed at exploring the different literatures and views in climate change and mine rehabilitation. It enlightens on past and current research in both these fields and further affirms the motivation of this study.

Chapter 3: This chapter outlines the materials and methods that are used in the study. Additionally, it explains the approach that this study will take further eliminating any other research approaches. Finally it presents some key aspects that need to be considered in the context of this study such as the limitations, assumptions as well as the delimitations.

Chapter 4: This chapter is the opening chapter of the main findings of the study. It is aimed at addressing the first objective of the study. It will make use of pictorial presentations of climate change impacts as well as mining areas in South Africa. Essentially, this chapter is attempting to determine whether mining regions are susceptible to impacts and which of those impacts are highly probable.

Chapter 5: This chapter is aimed at addressing the second objective of the study. It brings forth some local and international guidelines on post closure and rehabilitation practices. Chapter 5, attempts to understand the legal framework as well as other voluntary standards that exist for the mining industry.
Chapter 6: This chapter aims to address a portion of the third objective. Sustainability reports are used as materials to understand what mining companies are currently addressing in climate change and whether rehabilitation is one of the priorities being addressed.

Chapter 7: This chapter aims to address the other portion of the third objective. Interviews with mining companies, consulting firms as well as academic institutions further enlighten on rehabilitation planning and climate change. This chapter aims to support the findings in chapter 6.

Chapter 8: This chapter concludes the main findings of the study. It is aimed at addressing the fourth and final objective. This chapter brings together examples where lessons can be taken from that can further address the topic being investigated.

Chapter 9: This chapter aims to collate the findings of Chapters 4, 5, 6 and 7 in a brief discussion. This discussion is further supported by findings of Chapter 8 is concluded addressing with recommendations.
Chapter 2

2 Literature review

2.1 South African mining industry

History and present
The mineral wealth of South Africa was first noted at the beginning of the 19th century, where diamonds and gold were the country’s first economical minerals that placed South Africa at the forefront of industrial activity (Reichardt, 2013). As a result, the new found wealth shifted the concentration of our economic revenue from being mainly agriculturally based to more minerals based (Reichardt, 2013). The growing mining industry continued and still continues to be the backbone of the country’s economy, not only producing substantial financial benefits but also employing a great proportion of South Africans (van Tonder, 2009; CoM, 2014; Reichardt, 2013).

According to the statistics produced by the Chamber of Mines of South Africa for the year 2013/14, the mining industry accounts for 8.3 % of the gross domestic product (GDP) (CoM, 2014). The South African gold mining industry in particular, accounts for 11.8 % of the worlds reserves where the gold mines situated in the Witwatersrand basin, South Africa, are the biggest gold mines in the world and are approximately 3000 meters below the ground (Korte et al., 2000; CoM, 2014). Other key mineral commodities of South Africa are Platinum group metals (pgm) and silver where 89.5 % and 90.5 % that is produced is exported for international sales, respectively (CoM, 2014). Furthermore, the coal sector contributes tremendously to the success of these other commodities as 95 % overall electricity used in power plants is generated from the coal mined in South Africa (CoM, 2014).

Contrary to the prosperous production levels of the minerals, is the constant vulnerability and degradation of the environment as a consequence of the exploitation, which results in waste generation during mining activities. When mining initially started in South Africa, during the 19th century, the main emphasis had been on the economic gains. The environmental problems, spanning from dust deposition to land degradation, associated with such an activity were but of little concern
(Reichardt 2013). The southern Africa mining industry contributes approximately 72.3% of the solid waste produced annually (Maboeta and Rensburg, 2003). Reichardt (2013) highlights in an in-depth analysis of the mining industry’s rehabilitation methodology, how environmental precautions were only taken in response to problems as opposed to preventative measures, since the production of waste was considered to be the unavoidable nature of the business. Furthermore, it is highlighted how any precautions taken towards environmental protection were thoroughly motivated by certain individuals in the different companies instead of the company taking full responsibility of the impacts. This attitude of decoupling mining activities from the environment, has led to numerous repercussions that have arisen generations later. Ecosystems’ functionality has been altered where exacerbated water pollution has become rife together with poor air quality (Reichardt 2013).

**Mining and the environment**

The very nature of mining requires that social and human capitals be used to exploit the natural capital which is then converted to financial and manufactured capitals. Generally, mining activities leave a noticeable impact on the environment, whether it being underground or on the surface (Bradshaw, 1997; Bell et al., 2001; van Tonder et al., 2009). The impacts seen on the environment differ according to the method of mining used as well as on the geological state of the area (Bell et al., 2001). Mining affects the environment through deteriorating air quality levels, water quality and quantity, and through soil contamination which, as a consequence, affects vegetation establishment and growth. Air pollution arises when gaseous compounds such as nitrogen oxides (NO\textsubscript{x}) and sulphur oxides (SO\textsubscript{x}) are emitted into the atmosphere through the combustion of coal as well as other minerals (Bell et al., 2001). Poor water quality has become apparent especially within the gold and coal mining areas, mainly due to acid mine drainage (AMD) resulting from the oxidation of pyrite, leaving highly acidic waters with high levels of total dissolved solids (TDS) (Bell et al., 2001; Bakatula, 2009). Additionally, (potable) water quantity has also arisen as a problem due to reduced surface runoff from rain water infiltrating through the underground mine workings (Bell et al., 2001). It is important to note that even though this water assists in replenishing ground water levels and increasing groundwater recharge; the poor quality severely reduces the quantities of high quality water at potable standards. Soils are also polluted by the contaminants that are transported by
water movement. Poor soil quality consequently affects the establishment and growth of vegetation in the area, as it has been shown that most vegetation is unable to tolerate high acidity and metal levels which cause increased levels of reactive oxygen species (ROS), further resulting in oxidative stress as the cell membranes die (Bell et al., 2001; Yadav 2010). There are; however, some plants that have developed detoxification mechanisms enhancing their ability to strive in contaminated areas (Yadav, 2010). Such plants are ideal for remediating contaminated mine areas.

What becomes of concern now is the rate at which pollutants are disposed of into the environment. This is not only true for the mining sector but also the agricultural sector as well as for other sectors which rely on the exploitation of the natural environment. As has been shown in Rockström et al. (2009), generally the natural environment has a way of balancing itself out to counteract negative systems that cause an imbalance; however, with increased frequency and quantity of these negative imbalances, the earth system is unable to counter the effects.

With the aforementioned negative mining effects on the environment (air, water and soil quality), coupled with increasing frequencies of contamination, the environment, particularly the soil which harnesses a great proportion of ecosystem functionality, becomes vulnerable. The largest effects manifest through soil erosion, accumulation of salinity and nutrient reduction (Scholes and Scholes, 2013). Poor soil quality is defined as the inability of the soil to function as a result of imbalances in the physical, chemical and/or biological properties (Sha-Sha et al., 2011). Vulnerability of soils is said to be brought about by the great dependence on external sources of nutrients, as industries deplete the naturally available reserves (Scholes and Scholes, 2013). External source dependence in the long term is not sustainable (Scholes and Scholes, 2013). The overall success of human beings and striving economies relies on key outputs seen for example in the agricultural industry thus the need to value soil fertility in all industrial activities (Egan, 2006; Scholes and Scholes, 2013).

Rehabilitation of the environment is then vital to assist in reducing the vulnerability of already disturbed land. Taking the entirety of ecosystem functionality, good soil quality is regarded as
the key component for successful rehabilitation (Bradshaw, 1997). Therefore, rehabilitation techniques aim to firstly attain good soil functionality to assist in vegetation establishment (Bradshaw, 1997; Yadav, 2010). Rehabilitation involves the introduction of tolerant vegetation to reduce soil erosion and accumulate nutrients through leaf litter (Bradshaw, 1997; Tongway and Hindley, 2004). Vegetation roots also act on the soil interface to distribute and exchange organic compounds benefitting both the plant and the soil (Bradshaw, 1997, Tongway and Hindley, 2004, Tongway, 2010). Plant roots are able to access chemical compounds that are inaccessible for microbial breakdown; such compounds are broken through physiological processes \textit{in planta} within tissues and deposited back into the soil in an accessible state (Bradshaw, 1997; Trapp and Christiansen, 2003; Bushey \textit{et al}. 2004; Larsen \textit{et al}. 2004). Maintaining good soil quality from the beginning of mine activities is important in order to facilitate successful rehabilitation, as will be seen further below.

Land degradation and rehabilitation are not the only concerns within the mining industry, climate change has been of a concern within the mining and metals industry since 2008 where it was ranked as the 5\textsuperscript{th} top risk facing the industry out of a possible 10 identified risks (EY, 2014). According to a report published by Ernst and Young which disclosed the top 10 risks for the mining and metals industry, climate change for the year 2014-2015 is one of the under radar risks that will affect the industry mostly through the implementation of regulatory and economic instruments to curb emissions and direct the mitigation pathway (EY, 2014).

\textbf{2.2 Climate change}

\textbf{The historic controversy}

The controversy surrounding the enhanced greenhouse effect (GHE), global warming and climate change has not only been focused on who is contributing to these aforementioned scenarios, but also the origins of these concepts have been questioned to a great extent. A review by van der Veen (2000) presents an argument that the origins of the greenhouse effect were discovered as early as 1681 by Edme Mariotte. Although not explicitly called the GHE, however; it was in these writings of 1681 that the first comparisons between the atmosphere and an intermediate glass surface were first discussed (van der Veen, 2000). Furthermore, calculations derived from the first principles of
calculus, based on the theories of physics, were presented by Joseph Fourier and Claude Pouillet in 1822 and 1838, respectively (Houghton, 1997; Fleming, 1999; van der Veen, 2000; Bolin, 2007). Fourier (1827) analysed the heat budget of the Earth and did not consider the resultant solar radiation exerted back to the planet due to gases present in the atmosphere (Fleming, 1999; van der Veen, 2000). Work done by Pouillet (1838) on the Earth’s total radiation inclusive of the atmosphere, further elaborated how heat energy waves could possibly be projected back onto the Earth’s surface hence causing a net warming effect on the surface (Fleming, 1999; van der Veen, 2000). The latter mentioned finding by Claude Pouillet, in essence, was the first time in scientific history that the GHE was qualitatively described taking into consideration the differing paths that radiative energy could explore in space with time. This idea was further expanded on by Tyndall (1865), where gaseous compounds such as carbon dioxide (CO$_2$) and water vapour (H$_2$O(g)) were included in the mathematical equations, and differing concentrations of these gases were found to be responsible for the changes in the climate.

Having considered the argument presented by van der Veen (2000), on the original author to document the greenhouse effect, it is also important to pay careful attention to the more recent debates surrounding climate change of whether such changes are still following the natural trajectory or the present changes are as a result of anthropogenic causes. According to Fleming (1998), many authors such as Theophrastus and Hume in the 1750s together with Fourier in the 1820s, have attributed changes in the composition of nature, to humans, and as a result such changes affected both the regional and possibly the global climatic conditions. At this point in history, the gases that were responsible for changes in the climate had not been quantified (Fleming, 1998; van der Veen, 2000). It was only in the late 19th century that Arrhenius (1896) published work to further elaborate that increases in CO$_2$ concentration does indeed contribute to the net warming effect of the globe, however; humans may not contribute significantly to global warming as natural processes in the sea serve to sequester CO$_2$. However, Arrhenius (1896) failed to firstly acknowledge that the sea is only able to dissolve CO$_2$ after millennia and secondly, he did not foresee the rapid increase in fossil fuel
use during the 20th century (Bolin, 2007). And it is with these imbalanced rates of natural procession that human activities have contributed to an increased warming effect of the planet as a whole.

It is also important to note that climate change, is in essence a natural phenomenon as identified by the scientists, some being mentioned above, who studied it in the past. Historic climate events have shown that the Earth’s system undergoes long periods of cooling (glacial) followed by shorter periods of warming (interglacial), which when combined occur at an approximate frequency of 100 000 years (IPCC, 2007). Climate change is thus defined as the predicted deviation of the climate from the mean, which occurs over long periods, characteristically in decades or longer (IPCC, 2007). Climate variability is seen to contribute to climate change; however, variability ranges in short to long time frames (IPCC, 2007). Some climate variables have been described as the El-Niño Southern Oscillation (ENSO) which is due to the coupled oceanic and atmospheric components, inter-hemisphere exchanges as well as troposphere-stratosphere which are atmospheric components and lastly large ice sheet movement which are within the oceanic component (IPCC, 2007). Similarly, variabilities with the climate are in most cases understood chaotic patterns.

Since climate change appears to be a normal natural event, what then causes concerns with the current state? The chemical reaction of burning fossil fuels, results in CO₂ as well as other GHGs as by products. These chemical compounds further increase the greenhouse effect by trapping the sun’s radiative rays, consequently increasing the Earth’s surface temperature. In the latest report (Fifth Assessment Report, AR5), the IPCC has announced that the planet is undoubtedly experiencing a net warming since the 1950s, furthermore both atmospheric and oceanic systems are experiencing increasing temperatures (IPCC, 2013).

**Intergovernmental Panel on Climate Change (IPCC)**

The IPCC, formed in Geneva in November 1998, is an institution that has been appointed to gather factual findings on climate change research that has been carried out across the globe (Agrawala, 1998; Hulme and Mahoney, 2010). The formation of the IPCC followed the short lived Advisory Group on Greenhouse Gases which was established in 1985 and disbanded in 1990 (Hulme and Mahoney, 2010; Mathiason and Bhandari, 2010). Its formation came after a great need for an
intergovernmental institution, unlike the Advisory Group on Greenhouse Gases, thus governments that were part of the World Meteorological Organisation (WMO) and the United Nations Environmental Programme (UNEP) Governance Council came together to discuss an institution that would provide good scientific findings on climate change (Argwala, 1998; Mathiason and Bhandari, 2010).

The panel consists of three Working Groups which work in parallel to address the physical science of climate change, the impacts, adaptation and vulnerability as well as the mitigation measures in response to climate change, investigated by Working Group I, II and III; respectively (Argwala, 1998; Mathiason and Bhandari, 2010). These working groups are further supported by Technical Support Units (TSUs) (Figure 2.1).

Figure 2.1: Structural dynamics of the IPCC (adapted from http://www.ipcc.ch/organization/organization_structure.shtml).

The IPCC generates two outputs, firstly the underlying detailed Assessment Reports (AR) from each Working Group as well as policymaker summaries for each Working Group (Argwala, 1998). These summaries are critically reviewed by governments across the globe (Argwala, 1998). The IPCC released AR 1, AR 2, AR 3, AR 4 more recently AR 5 in 1990, 1995, 2001, 2007 and 2014. In all these assessments, the IPCC has been steadily integrating climate change into sustainability principles of countries around the world (IPCC, 2015).
There is consensus that the IPCC has greatly contributed to the knowledge sharing on matters pertaining to climate change, greatly straddling the boundaries of scientific sound delivery as well as politically acceptable conclusions (Argwala, 1998; Hulme and Mahoney, 2010). Although much debate has surrounded the causal factors of climate change, the IPCC has generated a scientific consensus showing that indeed climate change is currently being exacerbated by human activity (Hulme and Mahoney, 2010).

South African events on climate change
South Africa has been actively involved in the climate change arena since 1994 when the National Climate Change Committee was first established to address matters raised by the first and second IPCC Assessment Reports (AR1 and AR2) published in 1990 and 1995, respectively (Lukey, 2011). Signing and ratifying the UNFCCC (1994 and 1997, respectively) to further acceding to the Kytoto Protocol in 2002, showed that the government was gaining momentum in partaking in the global debates. Policy implications for the country became apparent when the third IPCC Assessment Report showed that South Africa is among the highest polluters within the developing nations and thus, as a response, the government initialised the National Climate Change Conferences (2005) as a prelude to the Long-Term Mitigation Scenarios (LTMS) in 2006 (Lukey, 2011). The LTMS process included stakeholders, government departments, civil society as well as businesses, among these mining companies as well. With other activities taking place nationally, such as the second National Climate Change Conference in 2009 as well as the UNFCCC COP 15 also in 2009, these built up to the National Climate Change Response Policy (NCCRP) White Paper published in 2011 (Lukey, 2011).

Current issues arising
The fifth report by the Intergovernmental Panel on Climate Change (IPCC) has a high confidence level that positive radiative forcing due to anthropogenic influences are causing a warming earth surface, and the largest contributor is CO₂ (IPCC, 2013). These anthropogenic influences are what lead to the enhanced GHE that is increasing the effects of climate change. Although in the past climate has been seen to change, this has been over thousand to millennia scales as compared to the currently seen high rates spanning over a couple of centuries (IPCC, 2007). The rising awareness of
changes to the current climatic patterns has resulted in more studies being carried out to obtain a better understanding of such changes. It has already been declared that areas within the tropical and subtropical regions of the globe are expected to be the most vulnerable to climate change as these areas are currently faced with elevated temperatures (Benhin, 2008; Turpie and Visser, 2013).

According the IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX), working on a medium confidence level, droughts may become more intense as a result of decreased precipitation and/or increased evapotranspiration (IPCC, 2012). A noteworthy point is that these predictions show more droughts in the western regions of South Africa while higher precipitation is expected in the north eastern regions of the country between the mid and the late 21st century (IPCC, 2013). Furthermore, the Department of Water, Agriculture and Forestry (DWAF) in South Africa has shown how the evapotranspiration rates experienced in the country are relatively high with only a small proportion of runoff accounting for this (DWAF, 2002). The quantification of the rainfall and evapotranspiration patterns also becomes problematic in the South African context as the western to eastern climatic gradients vary significantly (DWAF, 2002; Turpie and Visser, 2013).

The vulnerability of the South African biomes to climate change is predicated to further increase as the frequency of wildfires, bush encroachment and alien invasive species increase due to high CO₂ concentrations which are a favourable condition (Davis, 2011; Vincent et al., 2011). The cumulative impacts of these vulnerability aggravators will continuously contribute to overall change of the current ecosystem dynamics resulting in biome shifts (Davis, 2011; Vincent et al., 2011). Ecosystem impacts that have already been identified are changes in the fynbos, succulent Karoo, grassland and savanna biomes with projected losses by the year 2050 (Bond and Midgley, 2000; Midgley et al., 2002; Davis, 2011).

Climatic conditions in South African

Extreme temperatures are already starting to be seen in the country. The South African Risk and Vulnerability Atlas (SARVA) has shown that in the summer of 2013/2014 Limpopo, the North West, the Free State, the Northern Cape as well as the Gauteng provinces experienced heat waves
with daily temperatures reaching 40°C (SARVA, 2014). Additionally, SARVA has shown that in the summer of 2013/2014, the Gauteng and Western Cape provinces experienced heavy floods, due to torrential rains which resulted in the closure of roads as well as flooding of communities and establishments in close proximity to rivers (SARVA, 2014).

Changes in extreme precipitation are also starting to be seen in the country. SARVA has shown that in the summer of 2013/2014, the Gauteng and Western Cape provinces experienced heavy floods, due to torrential rains which resulted in the closure of roads as well as the flooding of communities and establishments surrounding rivers (SARVA, 2014). The western regions of the country are expected to experience significant droughts, increasingly as this century ends (DEA, 2013). Long Term Adaptation Scenarios (LTAS), using the dynamically downscaled projections for the A2 scenario, show that the western regions of South Africa will experience drying conditions starting from the short term (2015 – 2035) and more increasingly in the long term (2080 – 2100). The northern regions of the country are also expected to get drier in the short term (DEA, 2013). Interior and eastern regions of South Africa are expected to start off with low rainfall in the short and medium (2040 – 2060) terms; however, high rainfall is expected to increase more especially in the long term (DEA, 2013).

In terms of mean temperatures that have been projected for this century, LTAS show that interior regions of the country will experience higher temperatures than the coastal regions (DEA 2013). Short term means range between 1°C and 2°C, medium term means range between 2°C and 3°C while long term range between 2.5°C and 5°C (DEA, 2013). Importantly, some scenarios project higher temperatures than 5°C for the long term (DEA, 2013).

In terms of mean precipitation, LTAS show that increased intensities and frequencies of floods will occur. Further resulting in sea level rise as has already been witnessed in Durban during March 2007 floods with tides reaching a height of 2.2 m (Niang et al. 2014). Projections show that western regions will dry starting from the short term and will become increasingly drier in the long term (DEA, 2013). Northern regions are projected to become drier in the short term. Eastern and
interior regions are expected to experience lower rainfalls in the short to medium term followed by high rainfall in the long term.

In terms of precipitation patterns; autumn, spring and summer seasons are expected to receive less rainfall and become drier, receiving 30mm/season less rainfall (DEA, 2013). This is likely to happen in the short term and become more exacerbated in the long term (DEA, 2013).

2.3 Ecosystem dynamics

Before discussing rehabilitation in detail, it is important to introduce the ecosystem concept. The ecosystem concept dates back to 1935 when Sir Arthur Transley first defined an ecosystem as a specified community which has both abiotic and biotic features, altogether creating an environment where transfers exist between the organisms and the environment that the organisms are in (Gordon, 2002; Pickett and Cadenasso, 2002). Additionally, the environment may be altered by both the abiotic and biotic features consequently affecting the resource availability for the organisms (Gordon, 2002). In summation, the development of certain organisms within an ecosystem is affected by abiotic and biotic features. Such features include climate, living and decomposing material, soil characteristics, energy circulation and the overall processes that link all the aforementioned (Gordon, 2002; Pickett and Cadenasso, 2002). Essentially, it is important to understand the spatial dynamics of a particular physical system in order to understand the effects that affect the organism present in its environment and so the ecosystem components cannot be decoupled according to the physical and biological realms.

Ecological restoration and rehabilitation

Restoration can be regarded as repairing a landscape to its naturally historic vegetation type to maintain the structure and functioning of the ecosystem (Aronson et al., 1993; ITRC, 2001; Cooke and Johnson, 2002). This form of repairing is associated with conservation of biodiversity and indigenous species (Aronson et al., 1993). According to the Interstate Technology and Regulatory Cooperation (ITRC) agricultural vegetation is not preferred for restoration purposes (ITRC, 2001).

Rehabilitation, similarly to restoration, aims to restore the ecosystem structure and functioning of a landscape; however, the historic vegetation type is replaced with species that are also
able to retain the functionality of the ecosystem (Aronson et al., 1993; ITRC, 2001; Cooke and Johnson, 2002). Even though indigenous species are also used in this form of repairing of degraded land, this alternative generates speedy establishment of the species and hence faster results (Aronson et al., 1993). Rehabilitation also encourages the use of mixed species to enhance the success of vegetation (ITRC, 2001).

A diagram depicting the possible responses to land disturbance (Figure 2.2) elaborates the differences between restoration and rehabilitation and also the respective environmental states that facilitates either form of repairing (Aronson et al., 1993). In a substantial number of literature references, the terms restoration and rehabilitation are used interchangeably. For the purpose of simplifying the present study, the term rehabilitation will be used to refer to both restoration and rehabilitation unless specifically stated otherwise.
Climatic conditions and rehabilitation

The previous sections have discussed climate change and rehabilitation separately, in order to fully explain what the two concepts entail. This study is focused on identifying how these two concepts interact (or the lack of interaction) with each other. The following sections will therefore attempt to link what has been discussed above in light of the aims of this study.

From the first stages of rehabilitation in South Africa, climatic conditions deemed to play a vital role in the establishment of vegetation on areas that are to be rehabilitated (Reichardt, 2013). The head of one of the first mine rehabilitation experiments in the 1960s, William Cook, identified how the success of different grass species is dependent on the climate variations and also the level of contamination present in the substrate (Reichardt, 2013). Further experimental work revealed how the substrate properties change with changing weather conditions, where such changes were due to rainfall patterns and temperature conditions (Reichardt, 2013). In its recent report titled “Adapting to
a Changing Climate”, the International Council on Mining and Minerals (ICMM) has unveiled other potential challenges to be expected with climate change. These are tailings dams’ possible structural collapse with intensified rainfall patterns since tailings dams have been documented to only withstand heavy flood events once in 10000 years (2011; ICMM, 2013). Additionally, the ICMM has outlined how vegetation used to rehabilitate waste deposits could change with climate change, and water availability may prove to be a further constraint in drought prone areas and hence appropriate rehabilitation species selection forms an intricate role (ICMM, 2013).

A study done by Nordstrom (2009) further reiterates how increasing temperatures coupled with intense infrequent flood events may result in higher levels of contamination in water reservoirs. Additionally, such weather conditions may further exacerbate the effects of acid mine drainage (AMD) as contaminant mobility may increase hence causing high concentrations in aquatic systems (Nordstrom, 2009). Therefore, from the previous findings and rationale, it can be said that chemical characteristics of the substrate to be rehabilitated vary greatly with changing weather conditions and essentially this will affect the success of the introduced vegetation and the long term rehabilitation of the area. As already suggested by Nordstrom (2009), post mine closure activities, especially those pertaining to rehabilitation, should be considerate of the effects of climate change in designing of the tailings (slimes dam capacity), covers for tailings, revegetation species selection and also in the waste pre-treatment plants.

Legislative requirements and regulatory risks

Topics surrounding mine rehabilitation and climate change cannot be discussed in the absence of legislative and regulatory requirements, especially in South Africa. Both internationally and locally there have been many discussions and debates as to what constitutes good closure practices. Although this will be discussed further in Chapter 5, the following sections will provide an introduction to some leading bodies that inform the mining sector.

The current environmental impacts seen in the mining industry have not arisen in recent years. Current conditions show the extent to which environmental legislations were not implemented in the past. When the mining industry started, predominantly in the gold fields of the Witwatersrand
in the 1800s, there were no consequences for environmental damage or any measures to address social ills that occurred (van Tonder et al., 2009). The first environmental legislation to be enforced in South Africa was in the 1980s, which focused mainly on safety, health and environmental legacies as the number of abandoned mines grew (van Tonder et al., 2009). Within this legislation, mine closure was described with a slight focus on surface rehabilitation (van Tonder et al., 2009). The first legislation that paid specific attention to environmental management was the Minerals Act, 1991 (Act 50 of 1991) (van Tonder et al., 2009).

As per the South African legislation, mining companies are required to address issues of contamination and subsequent rehabilitation where necessary. The Mineral and Petroleum Resources Development Act (MPRDA) 28 of 2002, the amendments to the MPRDA 28 of 2002 together with the National Environmental Management Act (NEMA) 107 of 1998 and the amendments to the NEMA 107 of 1998; have stipulated the requirements for minimisation of contamination and rehabilitation, and the legal repercussions thereof. Furthermore, such requirements span to perpetuity post-closure, additionally holding the mining companies accountable even after the minerals have been exploited. Additionally, any right holder should make the appropriate financial provision towards the post-closure phase to ensure that all the cost implications are addressed for effective rehabilitation. There are other international guidelines that have stipulated some voluntary measures that may be adhered to, to certify corporate social responsibility and provide the benchmark for best practices.

**International Council on Mining and Minerals (ICMM)**

The ICMM, first initiated in 1999, is a CEO-led industry group that provides support to members and encourages sustainable development within the mining and metals sector. It was formed when large global mining houses appreciated that the nature of their business resulted in severe environmental and social problems and thus the sector needed a different approach to maintain good profits and reduce the vast risks that confronted the sector.
Mining, Minerals and Sustainable Development (MMSD)
The MMSD was a research programme; convened by the World Business Council for Sustainable Development (WBCSD) and hosted by the International Institute for Environment and Development (IIED); which independently published the findings of the Global Mining Initiative (GMI) (Buxton, 2012). The MMSD was purely mandated to carry through with the findings and recommendations made by the IIED concerning social development and environmental performance within the mining and minerals sector (Buxton, 2012). The project thus produced findings in the year 2002, which were thought to be game changing within the mining and minerals sector globally.

Interstate Technology and Regulatory Council (ITRC)
The ITRC, established in 1995 and reporting to the Environmental Institute of the United States of America, is a public-private partnership aiming to use novel technologies within the remediation field of contaminated lands, so as to contribute to minimising contamination risks while reducing remediation costs (ITRC, 2009). This organisation is based in the United States of America; however, the techniques presented by this organisation are employed in many remediation programmes across the globe (ITRC, 2009). The documents produced by the ITRC are used by specialists and professionals within the mining and minerals sector to evaluate, implement as well as align strategies with regulatory principles of the nations across the world.

Monitoring and reporting
Finally, it is also important to review what monitoring and reporting consists of, especially for the mining industry. Although this study is not aimed at debating the flaws within the GRI guidelines nor does it intend to critique qualitatively the sustainability reporting guidelines as presented by the GRI; reviewing what the guidelines entail is important in understanding the content reported by companies. The following section will therefore briefly introduce and discuss the GRI and elements that are particular the mining industry.

Global Reporting Initiative (GRI)
The Coalition for Environmentally Responsible Economies (CERES) in partnership with the United Nations Environment Programme (UNEP) created the Global Reporting Initiative in 1997 (CSR, 2013). The GRI mainly aims to increase the level at which sustainability issues –
predominantly environment and social – are dealt with within the corporate environment, in such a manner that sustainability issues are on par with the more widely reported economic issues (CSR, 2013). As part of this development, a vast web of networks has been created ranging from corporate companies, non-governmental organisations (NGOs) within the environment and social spheres, as well as accounting firms; which have formed strong global strategic alliances with other organisations such as UNEP, the International Organisation for Standardisation (ISO), United Nations Global Compact (UNGC) as well as the Organisation for Economic Cooperation and Development (OECD) (CSR, 2013; GRI, 2014). Finally, the Sustainability Reporting Framework created by the GRI ensures that companies are reporting on key performance indicators within the economic, environmental, social, and governance themes (GRI, 2014).

The reporting guidelines by the GRI are the most recognised both locally and internationally (King Committee, 2009; SAICA, 2011). Currently the GRI is at the 4th generation of its guidelines known as G4 which were released in 2013 (GRI, 2014a). The first, second and third generations were released in 2000, 2002 and 2006; respectively (GRI, 2014a). At each phase of the generational releases, the GRI has grown in its ability to scope specific issues and also in strengthening alliances across the globe.

As part of the sustainability reporting framework recommended by the GRI, companies are to report on their annual data which also allows for year-on-year comparisons for each company as well as among its competitors in that sector (GRI, 2014). For the purpose and scope of this study, G3 guidelines will be the focus as the data sampled from was between 2011 and 2013, before the G4 Guidelines were implemented. In the GRI G3 Guidelines, there are a total of six indices that each have indicators which assist with the reporting ( ).
Table 2-1: GRI G3 indices, indicators and aspects covered by each of the six indicators.

<table>
<thead>
<tr>
<th>Index Number</th>
<th>Economic</th>
<th>Environment</th>
<th>Labour Practices and Decent Work</th>
<th>Human Rights</th>
<th>Society</th>
<th>Product Responsibility Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator</td>
<td>9</td>
<td>30</td>
<td>14</td>
<td>9</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Aspects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economic</td>
<td>o Economic performance</td>
<td>o Materials</td>
<td>o Employment</td>
<td>o Investment and procurement practices</td>
<td>o Community</td>
<td>o Customer health and safety</td>
</tr>
<tr>
<td></td>
<td>o Market presence</td>
<td>o Energy</td>
<td>o Labour/management relations</td>
<td>o Non-discrimination</td>
<td>o Corruption</td>
<td>o Product and services labelling</td>
</tr>
<tr>
<td></td>
<td>o Indirect economic impacts</td>
<td>o Water</td>
<td>o Occupational health and safety</td>
<td>o Freedom of association and collective bargaining</td>
<td>o Public policy</td>
<td>o Marketing communities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Biodiversity</td>
<td>o Training and education</td>
<td>o Child labour</td>
<td>o Anti-competitive behaviour</td>
<td>o Customer privacy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Emissions, effluents, and waste</td>
<td>o Diversity and equal opportunity</td>
<td>o Security practices</td>
<td>o Compliance</td>
<td>o Compliance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Products and services</td>
<td>oOverall</td>
<td>o Indigenous rights</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

According to the GRI G3 Guidelines, one of the economic indicators requests companies to state financial implications, risks as well as opportunities that may arise due to climate change (GRI, 2006). Additionally, as part of the environmental index, companies are to report on biodiversity plans they have in place which contain measures to prevent, manage and remediate disturbed and contaminated sites (GRI, 2006). The Guidelines also find it relevant for companies to set aside remediation costs in cases for when environmental contamination occurs (GRI, 2006).

To support the general reporting Guidelines by the GRI, there are sector supplements which are tailor made to suit particular sectors. The mining industry uses the Mining and Metals Sector Supplement which aims to enhance transparency in sustainability matters for a sector that faces much criticism from stakeholders around the globe (GRI, 2010). It has been identified that within the mining sector, good reporting and disclosure have gained momentum and therefore the GRI supplement has the capability to improve the strides that have been taken already (GRI, 2010). The supplement is integrated fully into the GRI Guidelines where additional mining sector comments are
provided (GRI, 2010). Furthermore, specific management approaches are detailed coupled with performance indicators and protocols (GRI, 2010).

The Mining and Metals Sector Supplement (MMSS) provides commentary on seven of the 30 environmental indices and further adds three mining specific indicators which all clarify on issues of closure planning, rehabilitation, ecosystem services (including climate regulation) as well as tailings disposal. The sector specific supplements ensure that stakeholders are provided with information on mining companies’ current and future plans for effectively managing environmental issues (GRI, 2010).

The MMSS clarifies how biodiversity should be viewed within the mining industry (GRI, 2010). It suggests that biodiversity not only includes ecosystem goods (e.g. freshwater) but also includes services (e.g. climate regulation) (GRI, 2010). Therefore, within the environmental indicator, companies are encouraged to monitor their performance related to the inputs as well as the outputs to the environmental (Error! Reference source not found.) (GRI, 2010). These include energy and water (inputs) as well as waste and effluents (GRI, 2010). Finally, the supplement also draws particular attention to closure planning, rehabilitation and ensuring that adequate closure costs are accounted for (Error! Reference source not found.) (GRI, 2010). Companies are also advised to provide the social, health, safety, environmental, governance and legal implications for every closure plan (GRI, 2010). However, the MMSS does not make specific reference to the identification and reporting of climate change related impacts such as those presented in the GRI Guidelines. In addition, both the GRI Guidelines and the MMSS do not make any association of how climate change impacts could affect rehabilitation.

Finally, when companies use GRI Guidelines to develop a report, it is recommended that companies state the level to which the GRI guidelines have been applied. From GRI G3 Guidelines, there are six different levels to which the Guidelines can be applied (Figure 2.3). The levels with any addition (+) sign show that the report has been externally assured (GRI, 2011). The application levels allow the readers of the report to gain an understanding as to the extent to which the report uses GRI
Guidelines and it also provides companies with a certain standard to strive for or alternatively maintain.
Table 2-2: GRI (as well as MMSS) requirements in terms of general climate change issues as well as rehabilitation.

<table>
<thead>
<tr>
<th>GRI Indicators and requirements</th>
<th>Suggested elements and requirements to report</th>
<th>MMSS Indicators and requirements</th>
<th>Suggested elements and requirements to report</th>
</tr>
</thead>
</table>
| **EC 2:** Financial implications and other risks and opportunities for the organisation’s activities due to climate change. | Compilation includes:  
1. Senior governance body considered climate change risks and opportunities.  
2. Report risks and/or opportunities posed by climate change that have potential financial implications for the organisation which include physical and regulatory risks, and competitive advantage opportunities.  
3. Report whether management has quantitatively estimated the financial implications (e.g., cost of insurance and carbon credits) of climate change for the organisation. | **MM 1:** Amount of land (owned or leased, and managed for production activities or extractive use) disturbed or rehabilitated | Compilation includes:  
1. This indicator should be reported in hectares.  
2. This indicator refers to land disturbed by the company’s operations.  
3. This indicator refers to land that is owned or leased and is being managed for production activities or extractive use.  
4. ‘Land’ may refer to sea, lake or river beds if appropriate.  
5. Report the following data:  
   o Total land disturbed and not yet rehabilitated (A: opening balance);  
   o Total amount of land newly disturbed within the reporting period (B);  
   o Total amount of land newly rehabilitated within the reporting period to the agreed end use (C);  
   o Total land disturbed and not yet rehabilitated (D= A+B-C; closing balance). |
| **EN 12 :** Description of significant impacts of activities, products, and services on biodiversity in protected areas and areas of high biodiversity value outside protected areas. (This indicator is also supported by MM 1, alongside) | Compilation includes:  
1. Identify significant impacts on biodiversity.  
2. Report nature of significance of direct and indirect impacts (e.g. pollution type, introduction of invasive species, habitat conversion, changes in ecological processes etc.)  
3. Report significance of direct and indirect impacts by listing the species affected, areas affected, duration of impacts and reversibility/irreversibility extent of the impact. | **MM 2:** The number and percentage of total sites identified as requiring Biodiversity management plans according to stated criteria and the number (percentage) of those sites with plans in place. | Compilation includes:  
1. Identify the total number of sites.  
2. Report criteria for deciding whether an area is in need of a Biodiversity Management Plan (BMP) (i.e. scale of impacts, sensitivity analysis, ecosystem services, potential post closure use, and business case/risk aspects).  
3. Report sites that need BMPs.  
4. Report sites that have BMPs which are already in operation. |
<table>
<thead>
<tr>
<th>EN 13: Habitats protected or restored</th>
<th>Compilation includes:</th>
<th>MM 10: Number and percentage of operations with closure plans.</th>
<th>Compilation includes:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Indicator refers to areas in which remediation is completed or areas that are actively protected.</td>
<td>1. Identify company operations that have closure plans.</td>
<td>1. Identify company operations that have closure plans.</td>
</tr>
<tr>
<td></td>
<td>2. Assess the status of the area based on its condition at the close of the reporting period.</td>
<td>2. Identify the company’s total number of operations</td>
<td>2. Identify the company’s total number of operations</td>
</tr>
<tr>
<td></td>
<td>3. Report the size and location of all habitat protected areas and/or restored areas, and whether the success of the restoration measure was/is approved by independent external professionals.</td>
<td>3. Report the number of company operations that have closure plans, and the percentage of the company’s total number of operations.</td>
<td>3. Report the number of company operations that have closure plans, and the percentage of the company’s total number of operations.</td>
</tr>
<tr>
<td></td>
<td>4. Report whether partnerships exist with third parties to protect or restore habitat areas distinct from where the organization has overseen and implemented restoration or protection measures.</td>
<td>4. Report on the overall financial provision for closure, or include a reference to the relevant financial statements.</td>
<td>4. Report on the overall financial provision for closure, or include a reference to the relevant financial statements.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EN 16: Total direct and indirect greenhouse gas emissions by weight</th>
<th>Compilation includes:</th>
<th>EN 17: Other relevant indirect greenhouse gas emissions by weight.</th>
<th>Compilation includes:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Indicate standard used to calculate GHG emissions.</td>
<td>1. Identify and report all Scope 1 emissions.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Identify and report all Scope 1 and Scope 2 emissions.</td>
<td>2. Identify and report all Scope 2 emissions.</td>
<td></td>
</tr>
</tbody>
</table>

| EN 18: Initiatives to reduce greenhouse gas emissions and reductions achieved. | Compilation includes: |
|------------------------------------------------------------------------------------------------------------------------------------|
| 1. Identify and report initiatives to reduce Scope 1, Scope 2 and Scope 3 emissions. |

<table>
<thead>
<tr>
<th>EN 30: Total environmental protection expenditures and investments by type.</th>
<th>Compilation includes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identify and report remediation costs.</td>
<td></td>
</tr>
<tr>
<td>2. Identify and report environmental management costs.</td>
<td></td>
</tr>
</tbody>
</table>
Figure 2.3: GRI G3.1 application level explanations and guides; adapted from GRI (2011).

**Johannesburg Stock Exchange (JSE) Socially Responsible Investment (SRI) Index**

The Socially Responsible Investment (SRI) Index, created in May 2004, has four broad aims which are to firstly, identify companies on the JSE which incorporate the triple bottom line issues of sustainability while also basing it upon good governance; secondly, present a tool which displays whether companies align their practices to local and international corporate responsibility standards; thirdly, inform investors that are also interested in the non-financial risks material to the company; and lastly, to add positively to good corporate business performance in South Africa (JSE SRI, 2013).

The criteria themes that are assessed as part of the entry requirements for the SRI Index are broadly Environment, Social and Governance (ESG) issues, where within each of these themes the following business areas are assessed: policy and strategy, management and performance as well as reporting (JSE SRI, 2013). Additionally, the Index requires that companies respond to climate change related challenges (JSE SRI, 2013). However, it is important to note that the JSE SRI Index does not specifically require companies to report according to the GRI.
2.4 Summary

In summation, on one hand, it has been shown how the South African mining landscape has evolved in terms of environmental performance and stewardship. However, past experiences still prove to be cumbersome with many legacy issues arising as a consequence of past activities. Additionally, good legal frameworks on environmental governance exist in the country further ensuring that the past does not repeat itself, especially in terms of post closure activities, contamination and rehabilitation. Having addressed the issue on physical mine closure, another challenge exists of the physical impacts of climate change that are likely to affect rehabilitation of degraded land.

The final state in which mined land is left in can be characterized as being vulnerable land. Additionally, climate change will result in numerous environmental changes affecting the weather in different regions. Therefore since mined land is already vulnerable due to many factors including poor vegetation establishment, climate change will pose an additional stress to such an environment.
Chapter 3

3 Research design and method

3.1 Research design

Nature of study

Scientific enquiry, is based purely on adopting a critical approach, devising methodological frameworks, testing the obtained results and presenting a product that is irrefutable, measurable and dependable (Claval 2001; Ashley and Boyd 2006). Furthermore, scientific enquiry forms its premise on deductive reasoning; mainly driven by the testing of hypotheses that are derived prior to executing the research (Ashley and Boyd 2006). Such is more commonly known as quantitative research. On the contrary, qualitative research focuses on establishing conclusions from the presented findings thus making this research approach an inductive reasoning based approach. Qualitative research, mainly used within the disciplines of Social Sciences and Humanities, forces the researcher to continuously interrogate the findings by reading and rereading the information until it forms a logical judgment (Neuman 2003; Ashley and Boyd 2006). The aim of such a research approach is to gain an understanding of the reality as envisioned by the participants through examining their words, actions and beliefs further placing humans at the centre, as conscious and able bodies of the study (Maykut and Morehouse 1994; Williams 2000; Ashley and Boyd 2006). Both quantitative and qualitative approaches, held to the core of the approach, the application of methodical rules to obtain high-class data that is free of errors and also precise (Ashley and Boyd 2006).

Environmental science research, in considering the interactions between humans and the environment, has by definition shifted from the fundamental descriptions of classical scientific research. Environmental Sciences, not only complex in the nature in which it spans across numerous disciplines, but also its dynamic features; makes it appropriate to be viewed under the approach of qualitative research (Ashley and Boyd 2006; Roudgarmi 2011). The current study is focused on interpreting arising themes, utilizing descriptive methods and, where possible, also present quantitative results to further understand the topic in a manner conducive to sustainable development. Thus environmental science within this study encompasses as well as seeks to extrapolate
understanding from other disciplines such as those in the traditional science discipline, the mining and minerals industry, in the political sector as well as within the governance sector. As reiterated by both Ashley and Boyd (2006) and Roudgarmi (2011), environmental science research has developed into a field of interdisciplinary explorations and thus qualitative approaches assist the researcher in interpreting phenomena transpiring in the natural environment. The time has come for hierarchical barriers, which consider the quantitative sciences (mathematics, physics etc.) at the top and the qualitative sciences (social science etc.) at the bottom, to be demolished in order to construct an integrated and interdisciplinary form of sciences (Ashley and Boyd, 2006). Importantly, quantitative and qualitative research approaches play a vital role in distinguishing certain foundational problems; however, such research needs to also be integrated with efforts of addressing the more pertinent current issues such as climate change (Lietaer, 2001).

Available research frameworks

Within the qualitative research approach sphere, there are three main theoretical paradigms that a particular research aim may follow. These are the positivist framework, the interpretivist framework as well as the critical framework (Henning et al., 2004). These are further elaborated on below.

Firstly, the positivist framework is determined in identifying the truth by the usage of quantitative research means, and additionally viewing the researcher and the subject being researched as being mutually exclusive entities (Creswell, 2003; Henning et al., 2004). As a result, this approach significantly hinders the researcher from adequately interacting with the non-tangible elements of the subject such as values and beliefs. Additionally, this framework aims to explain and predict a phenomenon that occurs using classical deductive scientific reasoning driven by hypothesis testing (Henning et al., 2004). Although this research theory extensively delves into the theme of objectivity, some main criticism of this approach have been that it does not consider personal values and beliefs that shape one's understanding as the theory is deeply entrenched in scientific accuracy (Creswell, 2003; Henning et al., 2004).
Secondly, the interpretivist framework is concerned with understanding intentions, values, meaning-making, find patterns and make inductive conclusions within a particular population, and thus produces findings in a descriptive manner that has been interpreted (Henning et al., 2004). Contrary to the positivist theory, it may appear to be slightly subjective as the researcher is interested in understanding certain elements through a lens of interpretation and multiple perspectives (Henning et al., 2004). However, such subjectivity can be eliminated by triangulating the sources of data to further gain a logical validation of the themes to be presented (Creswell, 2003). Qualitative methods of data collection are employed for this theory as such an approach best optimises the framework (Henning et al., 2004).

Lastly, the critical framework aims to deconstruct the very norms that have been established through policy and are thus socially acceptable (Henning et al., 2004). This approach not only attempts to emancipate individuals from uniform social constructs but also ignites critical and conscientiousness rationales (Creswell, 2003; Henning et al., 2004). Creswell (2003), Henning et al. (2004) as well as Merkl-Davies et al. (2011) elaborate further on this approach; however it is not used in the current study.

**Research framework for current study**

With reference to the abovementioned research frameworks, this study will take on the interpretive research framework. Such a framework is adopted since the aim of the study is to assess whether rehabilitation programmes from South African mining companies have considered the impacts of climate change. Furthermore, the study hopes to gain a better understanding of why and how climate change is considered (if it is considered) or why it is not considered (if it is not considered). The broad objectives of the study are, to firstly establish whether the chosen South African mining companies are susceptible to the impacts of climate change; secondly, to examine whether local and international post closure guidelines make reference to climate change at rehabilitation; thirdly, to investigate whether identified companies have actually considered climate change at the rehabilitation phase and lastly, to review case studies which have directly and indirectly considered climate change during rehabilitation.
The positivist research approach is not appropriate as the study does not aim to gather quantitative data in search of proving or disproving a particular hypothesis in light of a general accepted scientific truth. The study is not particularly concerned with extensively quantifying the amount to which climate change has been intergraded into rehabilitation planning but rather to qualitatively describe the elements that have been considered and describe how these have been considered thus understand the extent to which climate change has been considered. The present study also does not aim to deconstruct principles and policies within which the topic of climate change and mine rehabilitation have been grounded in (i.e. question whether climate change is occurring etc.), such as in the critical framework, but rather hopes to present a possible framework and way forward to understand climate change implications in light of rehabilitation.

As has been recommended by other studies within the Environmental Sciences domain, a qualitative approach best suits this study due to the interdisciplinary nature of the study (Ashley and Boyd, 2006; Roudgarmi, 2011). Additionally, Ashley and Boyd (2006) as well as Conacher (1978) have articulated that environmental research balances two aims, that of firstly enhancing positive impacts while reducing the negative through understanding social views, and secondly of policies to further devise an interpreted balanced understanding of the issue at hand.

3.2 Research approach

Ultimately, the current study will be using a qualitative approach comprising of content analysis further exploring the content by interpretation. Researchers such as Ashley and Boyd (2006), Beck et al. (2010), Haque and Deegan (2010), Dawkins and Fraas (2011) as well as Roudgarmi (2011) have shown how interpretive content analysis can fully address the aims and objectives of a qualitative study within environmental sciences, environmental accounting, climate change disclosure, environmental reporting and environmental management. Such a research approach also calls for the researcher to be deeply immersed in the subject and to additionally be thorough throughout the execution of the study (Henning et al., 2004). Therefore such an approach is time consuming.
Although interpretive content analysis is recommended in such a study, it is important to note that such an approach may also present some limitations. As Dawkins and Fraas (2011) have shown, such a technique is time consuming and thus is more effective for small samples which can be investigated thoroughly, as opposed to a large sample size which will place tremendous time constraints on the researcher thus not allowing enough time to interact with the content. Therefore, as will be seen (Chapter 6, 7 and 8), the number of investigated sources was cautiously compressed to allow for an encompassing understanding while also keeping concise. A limitation of content analysis that has been outlined in a study by Beck et al. (2010) is that of aggregating a score based on a particular benchmark which may have its subjectivity. However, since this present study is only employing a pure qualitative approach as opposed to a positivist approach, such a limitation is not of concern. Another limitation presented by Beck et al. (2010), is that content analysis may either be skewed towards attempting to convey a meaning from some text or alternatively be more inclined to developing coding schemes which are unable to capture the essence of meanings. However, this study, as already mentioned, is only interested in qualitatively exploring climate change considerations which will be done so by reading and rereading the selected texts and then only attempting to summarise and code certain larger texts. The aim of the study will only be achieved through the detailed investigation (meanings and relationships) of content which can be further disassembled to gain in depth meaning of the topic (Roudgarmi, 2011). It has also been shown that topics such as those in the environmental sphere are vast and thus qualitative content analysis is able to unite the different streams creating a coherent delivery (Roudgarmi, 2011).

3.3 Data sources, collection and analysis

The current study is based in South Africa, although some international examples (Chapter 7) have been obtained, it is important to note that these cannot be simply mirrored onto the South African context as regulatory and geographic elements differ. The international examples are highlighting the underlying leadership dynamics that promote climate change considerations and also showing how and why such decisions are made. These examples will also attempt to highlight the challenges experienced. As already mentioned, for triangulation purposes, the study used a variety of data sources. Each objective focused on a different data source which is all combined at the end to
address the aim of the study. Thus the subsequent sections will be discussing how interpretive content analysis will be applied for each objective.

Objective 1 (Chapter 4)

The first objectives was to display the general predicted environmental changes associated with the impacts of climate change in South African provinces where mining activities are currently being pursued. Data of climate change predictions were the main source. Although widely available, care was taken in using such data, as central to the climate change debate is the credibility of the data presented. Therefore, care was taken to obtain data that are not from bodies that are politically motivated or those of non-governmental institutions as both sources may contain highly skewed findings that best motivates their own agenda. As stated at the beginning of this study (Chapter 1) all climate change information presented is in line with that produced by the IPCC. Thus the data was sourced from the Council for Scientific and Industrial Research (CSIR), the South African Department of Environmental Affairs (DEA), the South African National Biodiversity Institute (SANBI) as well as from the toolbox prepared by the South African Department of Science and Technology (DST) known as the South African Risk and Vulnerability Atlas (SARVA). All these institutions are credible and produce peer reviewed work that has been prepared by experts. Work from such institutions is also used to inform policy direction in South Africa as seen in the National Climate Change Response Policy (NCCRP), National Development Plan (NDP), Long Term Adaptation Scenarios (LTAS), Long Term Mitigation Scenarios (LTMS), Desired Emissions Reduction Outcomes (DEROs) etc. Additionally, the maps used have been downscaled from the Global Climate Models (GCMs) with efforts to show more refined trends at the regional and local levels. Importantly, these maps are possible representations of future trends which are based on the IPCC confidence level.

The selected mining companies are located across South Africa and mine different commodities (Table 3-1). Data of 17 mining companies (Appendix 4) locations - of which 16 are listed on the Johannesburg Stock Exchange (JSE) Socially Responsible Investment (SRI) Index - were sourced from the individual mining company by browsing through the website as well as through
published reports (DeBeers, although not part of the JSE SRI Index, was added onto the list since it represented a region on the western coast of the country). These locations were then plotted by using Google Earth as well as Google Maps. The actual locations were plotted by overlaying imagery layers on the South African map. The product of this was a South African map with mining locations (Chapter 4).

As a final step, the various climate change layers were overlaid onto the South African maps with mining regions. This created a map showing both the different climate change impacts and the mining locations. The layer created was saved as a file and edited using Microsoft tools.
Table 3-1: An alphabetically ordered list for the mining companies that will form part of the study obtained from the JSE SRI index.

<table>
<thead>
<tr>
<th>Company name</th>
<th>Brief Description</th>
<th>Commodities mined</th>
<th>Type of operations</th>
<th>Province(s) of operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>African Rainbow Minerals</td>
<td>South African based diverse mining and minerals company.</td>
<td>• Platinum</td>
<td>• Underground</td>
<td>Kwa-Zulu- Natal, North West, Northern Cape, Limpopo, Mpumalanga</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ferrous</td>
<td>• Opencast</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Coal</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Copper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anglo American Platinum</td>
<td>World leader in Platinum Group Metals (PGMs) producing 40% of the world's platinum.</td>
<td>• Platinum Group Metals (PGMs)</td>
<td>• Underground</td>
<td>Limpopo, Mpumalanga, North West</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Opencast</td>
<td></td>
</tr>
<tr>
<td>Anglo Gold Ashanti</td>
<td>AngloGold Ashanti has 20 gold mining operations in 10 countries, as well as several exploration programmes in both the established and new gold producing regions of the world.</td>
<td>• Gold</td>
<td>• Underground</td>
<td>Free State, Gauteng, North West</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Opencast</td>
<td></td>
</tr>
<tr>
<td>BHP Billiton</td>
<td>Global resource company which is among the highest producers of major commodities.</td>
<td>• Aluminum</td>
<td>• Underground</td>
<td>Gauteng, Kwa-Zulu Natal,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Manganese</td>
<td>• Opencast</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Nickel</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Coal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DRD GOLD Limited</td>
<td>South African gold producer and the leading company that specialises in gold retreatment of surface tailings.</td>
<td>• Gold</td>
<td>• Underground</td>
<td>Gauteng</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Opencast</td>
<td></td>
</tr>
<tr>
<td>Exxaro Resources</td>
<td>South African based diversified resource company with other operations in Botswana, the Democratic Republic of Congo, Inner Mongolia and Australia.</td>
<td>• Coal</td>
<td>• Underground</td>
<td>Gauteng, Kwa-Zulu Natal, Limpopo, Mpumalanga, Northern Cape</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ferrous</td>
<td>• Opencast</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Titanium dioxide</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Base metals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gold Fields Limited</td>
<td>Global producer of gold with operations in Australia, Ghana, Peru and South Africa</td>
<td>Gold</td>
<td>• Underground</td>
<td>Gauteng</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Opencast</td>
<td></td>
</tr>
<tr>
<td>Company Name</td>
<td>Brief Description</td>
<td>Commodities mined</td>
<td>Type of operations</td>
<td>Province(s) of operation</td>
</tr>
<tr>
<td>------------------------------</td>
<td>------------------------------------------------------------------------------------</td>
<td>-------------------</td>
<td>--------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Harmony Gold Mining Company Limited</td>
<td>Thirds largest world producer in the World with operations situated in South Africa and Papua New Guinea</td>
<td>• Gold</td>
<td>• Underground Opencast</td>
<td>Free State, Gauteng, North West</td>
</tr>
<tr>
<td>Impala Platinum Holdings</td>
<td>A South African and Zimbabwean based platinum group metals resource company</td>
<td>• Platinum Group Metals (PGMs)</td>
<td>• Underground Opencast</td>
<td>Free State, Gauteng, North West</td>
</tr>
<tr>
<td>Kumba Iron Ore</td>
<td>An iron ore resource supplier that forms part of the Anglo American plc group</td>
<td>• Iron ore</td>
<td>Opencast</td>
<td>Limpopo, Northern Cape</td>
</tr>
<tr>
<td>Lonmin plc</td>
<td>One of the world’s largest primary producers of Platinum Group Metals (PGMs).</td>
<td>• Platinum Group Metals (PGMs)</td>
<td>• Underground Opencast</td>
<td>Limpopo, North West</td>
</tr>
<tr>
<td>Northman Platinum Limited</td>
<td>Platinum Group Metals (PGMs) mining, processing and marketing company based in South Africa.</td>
<td>• Platinum Group Metals (PGMs)</td>
<td>• Underground Opencast</td>
<td>Limpopo, Mpumalanga, North West</td>
</tr>
<tr>
<td>Royal Bafokeng Platinum</td>
<td>Black owned Platinum Group Metals (PGMs) producer operating in the North West province of South Africa.</td>
<td>• Platinum Group Metals (PGMs)</td>
<td>• Underground Opencast</td>
<td>North West</td>
</tr>
<tr>
<td>Sasol (Mining)</td>
<td>International integrated energy and chemical company that also produces low-carbon electricity.</td>
<td>• Coal</td>
<td>Opencast</td>
<td>Mpumalanga</td>
</tr>
<tr>
<td>Sibanye Gold</td>
<td>South African gold mining company with three major operations based in two provinces.</td>
<td>• Gold</td>
<td>• Underground Opencast</td>
<td>Free State, Gauteng</td>
</tr>
<tr>
<td>DeBeers Group</td>
<td>The De Beers Group of Companies was established in 1888. De Beers are the world’s leading diamond company, with unrivalled expertise in diamond exploration, mining and marketing diamonds</td>
<td>• Diamonds</td>
<td>• Underground Opencast</td>
<td>Limpopo, Free State, Northern Cape</td>
</tr>
</tbody>
</table>
Objective 2 (Chapter 5)

The second objective was to review local and international guidelines on post closure practices. The documents were collected online from the websites of the following institutions: the ICMM; Mining, Minerals and Sustainable Development (MMSD), Interstate Technology and Regulatory Council (ITRC), the South African Chamber of Mines (CoM); and the following legislations were sourced from the respective South African government websites (National Environmental Management Act (NEMA), Minerals and Petroleum Resources Development Act (MPRDA) and the National Water Act (NWA)). These documents address issues of closure and rehabilitation planning. The documents were stored in appropriately named files. The documents were named in codes according to the institutions name as well as the year in which the document was published. This further assisted with ease of access of the documents during analysis.

For detailed content analysis, the identified documents were analysed by firstly studying the table of contents of the documents to familiarise one with the general layout of the document. Following this, the report was scanned through, observing the content layout and the use of imagery that may be of assistance. This step also allowed one to gain a better grasp of the documents structure and the numerous subjects that were presented. The executive summary, if available, was reviewed to obtain a holistic understanding of what the document contained together with the aims, objectives and findings within the document. Document analysis then followed in a qualitative structured manner. From the extensive literature analysis that had been conducted, key words were generated to further assist in determining whether the reviewed guidelines mention climate change directly or indirectly. The following key words were used to identify important as well as relevant sections within the documents: biodiversity, carbon, clean-up, climate, climate change, closure, droughts, emissions, environment, floods, greenhouse gases, global warming, heat, management, rainfall, rehabilitation, remediation, risk, temperature, vegetation, water. These key words were only used to draw one to the important and relevant sections of the document; these keywords were not used to generate a frequency count as sometimes done in qualitative research.
Objective 3 (Chapter 6: Reporting)

The third objective was to investigate whether mining companies operating in South Africa have considered the impacts of climate change, especially post closure. To fulfill this objective, data was collected from two different sources, firstly through reports and secondly through interviews.

A purposive sample methodology was employed for this research objective to gain a better understanding of the subjects being investigated at hand. A total of 16 mining companies listed on the JSE SRI Index, as well as one additional mining company situated in the western coast of South Africa (De Beers) were sourced and used for the first part of this objective. Such companies are expected to practice good sustainability endeavours (JSE SRI Index, 2013). Additionally, qualification to be listed in this index, among other criteria, is to report on climate change and the predicted effects that could pose a business risk (JSE SRI Index 2013). The JSE SRI Index (2013) also stipulates that listed companies are to meet senior responsibility, climate change commitment as well as emissions disclosure which span across policy/governance, management/strategy and disclosure. However, it is important to note that what is reported in sustainability reports by a company is only a sample of the company’s activities. Thus, there may be cases where companies may be engaging in some activities and these may not be reported on. Therefore publically reported information may present a limitation, as opposed to conducting interviews. A total of 16 companies were mining companies out of the 72 listed on the JSE SRI Index for the year 2013.

For the first part of the objective (Chapter 6), Sustainable Development (SD) Reports are used to understand whether mining companies have considered the impacts of climate change especially at the rehabilitation phase. Sustainable Development Reports are a piece of communication between the mining companies and external parties (ranging from shareholders, to stakeholders as well as to the general public) (GRI, 2006; GRI, 2013). Thus, SD Reports are a transparency tool showing that the company is measuring, disclosing as well as being accountable in sustainability matters that are both positive and negative (GRI, 2006; GRI, 2013). There are three pertinent reasons why this study will focus on sourcing data from SD Reports. Firstly, as per the GRI G3 Reporting Framework, companies are required to disclose on climate change risks as both environmental and economic indicators; furthermore,
remediation programmes specifically for industries that are likely to contaminate the natural environment are required to be reported on (GRI, 2006). Secondly, companies that are listed within the JSE SRI Index are also required to publicly disclose issues related to sustainability and these can be conveyed in either Annual and/or Integrated Reports or alternatively in SD Reports. Having considered the latter reason, one may question why then are Annual and/or Integrated Reports not reviewed as well? This is due to the third reason which is that research carried out by Unerman (2000), Azapagic (2004), Beck et al. (2010) as well as Haque and Deegan (2010), has shown that substantially more information pertaining to climate change and rehabilitation is disclosed in SD Reports as opposed to Annual Reports or Integrated Reports. This has been attributed to the fact that the GRI guidelines provide more specific categories to consider which may not necessarily transpire in other reports.

In addition to the abovementioned, although great criticism has been placed on the nature of reporting especially within the mining sector, Beck et al. (2010) has argued that voluntary reporting instruments do raise an awareness of environmental issues. Published reports do not only show investors the level of accountability that the company has, but it also displays some level of commitment to mitigate the business risks that transpire (Haque and Deegan., 2010). The ability of a company to disclose is associated with leaders within the company wanting to develop a transparent network which further affirms good governance over and above effective leadership (IoDSA, 2009).

Having mentioned the string of events that took place in South Africa in the literature review which pertain to climate change awareness within government, Sustainability Reports published from 2011 to 2013 were reviewed as these are most likely to show climate change considerations in the country at a time when government policies together with international policies were showing great strides in development. This time frame also falls within the boundaries of the G3 and G4 Reporting Frameworks as well as the fourth and fifth IPCC Assessment Report and also after the ICMM Integrated Mine Closure Toolkit. (ICMM, 2008; Lukey, 2011; GRI, 2013; IPCC, 2013).

For detailed content analysis, the identified documents were analysed using a similar methodology to the policy document analysis done for objective 2 above. Firstly, the table of contents of
the report was studied to familiarise one with the general layout of the document. Following this, the report was scanned through, observing the content layout and the use of imagery that may be of assistance. This step also allowed one to gain a better grasp of the report and the numerous subjects that were presented. The following keywords were then searched within the document, as recommended by Haque and Deegan (2010), to further understand which sections discussed both climate change and rehabilitation related topics: biodiversity, carbon, clean-up, climate, climate change, closure, droughts, emissions, environment, floods, greenhouse gases, global warming, heat, management, rainfall, rehabilitation, remediation, risk, temperature, vegetation, water. These words were extracted from the literature concerning the topic of the study (Chapter 1 and Chapter 2).

Objective 3 (Chapter 7: Interviews)
As the second part of the objective which was to investigate whether mining companies operating in South Africa have considered the impacts of climate change, especially post closure; a total of 13 interviews were conducted with persons from mining companies, consulting firms as well as academic institutions. The persons that were interviewed were in the following departments or research fields: environmental management, closure planning, mine rehabilitation/restoration, sustainable development and technical solutions (Appendix 5). Prior to the participants being interviewed, they were provided with a detailed participation information sheet (Appendix 1a), a sheet requesting permission to conduct the study (Appendix 1b), a consent from (Appendix 1c), as well as the ethics clearance certificate (Appendix 1d). Interviews were conducted in person, and where this was not feasible, telephonically. All participants were asked semi structured open ended questions (Appendix 1e, 1f and1g). The questions covered themes in; (i) the awareness of climate change, (ii) climate change impacts on the running of the business and further risks associated, and (iii) mitigation and adaptation measures in place in response to climate change projections.

During the interview process, responses from the participants were recorded using hand written notes. The notes were then transcribed onto word documents where the documents were named using codes to further ensure the confidentiality of the participants. The transcribed data was then critically analysed to identify the common themes. These were inserted onto an excel spreadsheet to gain a better
perspective of the main trends. For responses that were nominal, IBM SPSS Statistics 22 was used (IBM SPSS Statistics 22.0 2013) to identify common trends and relationships and further generate frequency graphs.

**Objective 4 (Chapter 8)**

The last objective was to review case studies of mining companies that have considered climate change at the post closure stage especially in their rehabilitation planning. To ensure continuity and easy comparability, a similar methodology was used for this chapter as that of Chapters 5 and 6. Additionally, all documents were read and re-read in greater detail as most of the information pertained in the document was all very important.

### 3.4 Data management

All the data collected from the websites as well as the interview data was stored in strictly coded files, according to the different objectives. Only Chapter 8 files used real names for storage purposes as the other chapters contained confidential data. Data for Chapter 5 and 6 were stored with identifying codes and also the year of publication as this formed an important part of the analysis. A single excel document and word document were used for each objective further ensuring that data are not mixed with other objectives. In instances where a single objective contained more than one component (e.g. Chapter 6), different sheets within a single document were used further assisting with easy comparisons. A side journal was also used throughout the study to record hand written notes of the subject.

### Ethical issues

Due to the nature of this research, ethics clearance was requested from the University’s Human Research Ethics Committee (non-medical). The ethics clearance certificate affirms that the data collected, especially for the interviews, was done so using University standards. Thus, all participants were made aware of the research together with the confidentiality contained. It was emphasised that the research is for academic purposes where no rewards would be given for participating. Additionally, participation in this study was entirely voluntary therefore participants that were approached could either agree to participate or alternatively not agree.
Delimitations, assumptions and limitations

**Delimitations**
- Although this study has presented the debates surrounding the issue of climate change, this can be seen as only a contextualising exercise to further enlighten on how awareness has increased with time. Thus, for the purpose of this study, climate change views are of those presented by the IPCC, the South African government as well as other research institutions in South Africa such as the CSIR, SANBI etc.
- Additionally, this study does not aim to interrogate the flaws that may be contained within the GRI guidelines nor does it intend to critique qualitatively the sustainability reporting guidelines as presented by the GRI. Many other reporting guidelines are present; however, for this specific study only the GRI sustainability reporting guidelines will be used and assumed to be the most credible at present as since these guidelines are deemed to be the most dominant (Ballou et al. 2006).

**Assumptions**
- This study was not aimed at interrogating the current climate change scepticism but rather accepts all the projections presented in the latest reports by the IPCC and other refutable local scientific bodies. And thus, the IPCC will be assumed to be true, credible and legitimate.
- The samples selected are based on the assumption that - due to being listed on the JSE SRI index, the Carbon Disclosure Programme (CDP), reporting using the GRI guidelines, being affiliated to the ICMM and numerous other credible organisations – these companies are the best in the industry showing exemplary behaviour.

**Limitations**
- The study focused on South Africa and thus can only potentially show what is happening in the South African context. Additionally, even though the study is based in South Africa it is important that the conclusions obtained are not fully generalized as a particular set of participants was targeted; who are thought to be representative of good practice standards. However, the findings do enlighten on key areas where various climate change impacts will occur.
• For triangulation purposes the study also used interviews as a form of data collection. However, interviews proved to be difficult to conduct as many mining participants refused to participate or could not assist due to the lack of knowledge, time/availability issues as well as structural reform within the company. Continuous efforts were made to contact mining participants. Communication ranged from multiple reminder emails to telephone calls (both averaged at five, per communication type). Additionally, data was to be sourced from government officials, consulting firms as well as academic institutions; however, similarly to the mining companies, many participants were not able to participate.

• Reviewing publicly available documents may also be taken to be a limitation since this is purely based on what the company would like to publically disclose. Other information pertaining to the company’s activities may not be explicitly mentioned in such documents to keep a competitive advantage. For example, some interviewed participants did disclose some useful information which is not available to the public; however, due to ethical consent, are not published in this study.

• The use of Sustainability Reports also poses a limitation since information captured as text is static as compared to interview data, which shows some level of dynamism as the participant is able to enlighten on historical and future activities. Thus the selected documents will only enlighten on what occurred within that company for those specific years. However, as supporting information, interviews further enlighten on the general awareness of climate change within the mining sector.

• Also important to take into consideration is how, in general environmental and climate change disclosures are relatively low compared to other categories, especially within the mining and minerals sector. Therefore such an element is bound to present a research constraint.

• In instances where Sustainability Reports were not available, Annual Reports or Integrated Reports were used as supplements. The latter mentioned were seen to be equivalents to the former in these special instances.
Chapter 4

4 Anticipated climate change impacts

4.1 Introduction

Having discussed the climate change debate and other relevant topics that construct the discourse such as sustainable development, mine rehabilitation and the likes, it is important to establish which areas of the country will be affected by what types of changes. As already discussed in the previous chapter, climate change will result in various environmental changes therefore this chapter will enlighten on the most important changes to be anticipated, specifically related to this study.

In presenting the objectives, the first objective was dedicated to displaying specific environmental changes associated with climate change in South Africa especially in regions where mining activities are being currently pursued. This objective assisted in further ascertaining what impacts are predicted in operational areas which will subsequently affect the area post mine closure.

This chapter will base the main findings around temperature increase, varying rainfall patterns as well as shifting vegetation distributions as these, as discussed in Chapter 2, may potentially affect mine rehabilitation the most. The methodology to producing imagery with both the effects and the mining regions has already been presented (Chapter 3). The findings of this chapter will arise throughout the subsequent chapters of this study.

4.2 Key findings and discussion

Anticipated changes

Studies and literature produced from credible sources both internationally and locally have shown that there definitely will be changes in precipitation, temperature as well as vegetation distribution in some regions of South Africa. The subsequent sections will thus elaborate pictorially what changes will be seen during which time frames.
**Increased temperatures**

On the global scale, temperature increases have been approximated to be in the range of 1.5°C and 4.8°C, however, this may be much higher in the tropics and subtropics (IPCC, 2013). The highest temperature increases are expected to be in the north-western arid interior of the country during the autumn and spring seasons (Figure 4.1). The western, southern and eastern coasts of the country are expected to be slightly cooler than the interior as the oceans regulate the coastal winds and temperature.

The mining areas situated around the Lowveld, Bushveld, Highveld and Great Karoo regions are most susceptible to high temperatures especially during the spring season where the interior regions of the Great Escarpment will experience marked increases in temperature (Error! Reference source not found.). Mines around the Namaqualand region appear to be continuously exposed to high temperatures throughout the seasonal variations of the year, whereas those situated in the eastern coastline of the country in the KwaZulu-Natal province appear to be less affected by the temperature increases throughout the year (Figure 4.1).

**Varying rainfall patterns**

The given projections from the IPCC show variability in the precipitation over the country by ~2050 with an increasing ~2050 with an increasing rainfall gradient moving from the west to the east. The southwestern regions of the country will experience drying conditions during the winter seasons, contrary to current patterns; while the southeastern regions on the exterior side of the escarpment will experience slight winter precipitation (Figure 4.2). The summer will result in higher precipitation levels especially on the eastern regions of the country especially in higher lying areas of the escarpment and further north towards the Lowveld as well as some parts of the Highveld and Bushveld regions (Figure 4.2: South African projected changes in total annual rainfall using GCM scenario A2 from the IPCC Fourth Assessment report for a) July (mm month$^{-1}$) and, b) December (mm month$^{-1}$) (Average rainfall adapted from Midgely et al., 2007 and DEA, 2013).)

Mining regions concentrated in the northeastern corner of the country, straddling the Lowveld, eastern Bushveld and northern Highveld will be susceptible to markedly higher precipitation levels, especially during the summer season. On the contrary mining activities in the central to western regions of the country will be exposed to droughts and less precipitation if at all (Figure 4.2). Midgley et al. (2007) and DEA (2013) has further stated that rainfall intensity is expected to increase in general which will be coupled with increased drought durations. However, even with increased rainfall intensity, the
high variability will result in less frequent storm flow events further jeopardising water reserves across the country.

Figure 4.1: South African median temperature change using the multimodal GCM scenario AR4 for annual seasons in 2050 during a) December, January and February (DJF), b) March, April and May (MAM), c) June, July and August (JJA) and, d) September, October and November (SON). Isolines (isotherm) representing the distribution of temperatures for South Africa with an increasing warming gradient towards the interior regions. (Average temperatures adapted from Midgely et al., 2007 and DEA, 2013).
Vegetation distribution

Due to the temperature and precipitation dynamics that have been predicted, soil moisture days are also consequently predicted to change as a result. The soil moisture variable shows the number of days where both temperature and soil moisture are appropriate for vegetation growth. In general, soil moisture days are expected to decrease on an east to west gradient (Figure 4.3). This is also a representation of when both soil temperature and moisture are conducive for plant growth thus these predictions show that towards the year 2050 the environmental conditions will become less favourable for plant growth (Figure 4.3: South African soil moisture days where both temperature and soil moisture are conducive of effective plant growth, a) in the year 1990 where CO$_2$ concentration is at 360ppm and, b) the prediction of the year 2050 where CO$_2$ concentration is at 550ppm using the older GCM depicting the extreme dry scenario. (Distribution layout adapted from Midgley et al., 2001).
Figure 4.3: South African soil moisture days where both temperature and soil moisture are conducive of effective plant growth, a) in the year 1990 where CO$_2$ concentration is at 360ppm and, b) the prediction of the year 2050 where CO$_2$ concentration is at 550ppm using the older GCM depicting the extreme dry scenario. (Distribution layout adapted from Midgley et al., 2001).

Closely coupled with the soil moisture days experienced, is the overall biome distribution which characterizes the vegetation dynamics of the country. The previously discussed climate changes in temperature and precipitation (Figure 4.1 and Figure 4.2) consequently affecting the soil moisture days (Figure 4.3: South African soil moisture days where both temperature and soil moisture are conducive of effective plant growth, a) in the year 1990 where CO$_2$ concentration is at 360ppm and, b) the prediction of the year 2050 where CO$_2$ concentration is at 550ppm using the older GCM depicting the extreme dry scenario. (Distribution layout adapted from Midgley et al., 2001)) will thus potentially impact the distribution of biomes across the country (Figure 4.4). Currently, the land is classified according to seven dominant biomes in the country (Figure 4.4). However, with climate change it is expected that all current known biome distribution will contract mostly towards the eastern regions of the country (Figure 4.4). The Grassland, Fynbos, Succulent Karoo as well as the Nama-Karoo are projected to be
the most severely affected where the Savanna biome may possibly experience an expansion (Figure 4.4: South African biome distribution; a) showing the current distribution of the major biomes in the country together with the common mining areas and, b) showing the projected biome distribution in the year 2050 using the General Circulation Model (GCM) C CSM emission scenario IS92a overlaid with the common mining areas. (Biome layout adapted from Midgley et al., 2001 Midgley et al., 2007 and DEA, 2013a).)

The major controller and stimulant in the Fynbos, Grassland and Savanna biomes is fire which ultimately determines the functionality of the landscape. With climate change, it is anticipated that there may be higher fire frequencies as a result of prolonged periods of dry conditions (Midgley et al. 2007).

4.3 Summary

In summation, it can be seen that the various attributes of climate change have a tremendous effect on the overall distribution of South African biomes. As can be seen, approximately 40% of the mining companies plotted will be affected shifting biome distributions, as we know them now.

Additionally, it has been established that vegetation growth and distribution is affected by temperature,
precipitation and soil moisture. It is important to note, that at this instance these are the ideal growth conditions of vegetation, with the exclusion of degraded and polluted mine soils. Thus it is important to understand future vegetation dynamics which assist in finding appropriate vegetation species to be used for mine rehabilitation. This will further ensure that mine rehabilitation achieves the actual goal and further promotes sustainable development within the country. The research question being answered here was will mining companies in South Africa be affected by climate change impacts? From the gathered information presented in this chapter, it is clear that the majority of companies will experience at least one climate change impact which may possibly affect rehabilitation success.

**Chapter 5**

5 **International guidelines, standards and recommendations on mine closure.**

5.1 **Introduction**

Prior to investigating the protocols and thoughts that mining companies have towards climate change, more especially in the rehabilitation phase of the mine lifecycle, it is important to consider both international and local guidelines and recommendations on closure. This is the essence of the second objective which is to review local and international guidelines on post closure practices. This chapter aims to introduce and highlight the general practices that have been recommended by both international and local bodies active in the mining industry.

Only mine closure sections of the documents are reviewed, as rehabilitation is mainly of active concern during the concurrent rehabilitation process and the closure planning phase. Although legislation requires that closure be considered from the inception of the project, it is important to note that historically, rehabilitation was only of major concern when the operational phase of the mine had almost reached its end point (J. Stacey, I. Watson, I. Weiersbye, pers. comm.). Nevertheless, reviewed documents were analysed in great analytical detail as described in Chapter 3. The selected documents were of both international and local origin to further highlight the expectation abroad as well as within the national context. Overall a total of 10 documents were analysed which consisted of four international
and five local documents (Table 5-1). The final document analysed is not related to mine closure practices; however, it aims to provide some context in the South African climate change regulatory environment. This document is the NCCRP which defines and describes South Africa’s position in the climate change environment.

Table 5-1: Chronological list of international and local documents reviewed.

<table>
<thead>
<tr>
<th>Year of publication</th>
<th>Documents title</th>
<th>Institution name</th>
<th>Year of publication</th>
<th>Documents title</th>
<th>Institution name</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>Mining for the Future</td>
<td>MMSD</td>
<td>1998</td>
<td>National Environmental Management Act</td>
<td>DEA</td>
</tr>
<tr>
<td>2006</td>
<td>Good Practice Guidance for Mining and Biodiversity</td>
<td>ICMM</td>
<td>1998</td>
<td>National Water Act</td>
<td>DWAF</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2011</td>
<td>National Climate Change Response Policy (White Paper)*</td>
<td>DEA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2013</td>
<td>Mining and Biodiversity Guideline: Mainstreaming biodiversity into the mining sector</td>
<td>DEA</td>
</tr>
</tbody>
</table>

*Although this document does not provide specific information on closure, it provides some context on the timescales within which rehabilitation policies and climate change policies were developed in South Africa.
5.2 Key findings

International context

Mining, Minerals and Sustainable Development (MMSD)

During 2002, MMSD published a Mine Closure Working Paper which was Appendix B of Van Zyl et al. (2002a). The document presents the objectives that all mine closure plans should have as well as the elements to consider during mine closure planning (Figure 5.1). The ideal situation of mine closure planning encompasses integrating closure plans while still at the feasibility stage, and constantly refining such plans as more information arises throughout the operational phase and closer to mine closure (also see Appendix 2). In developing the objectives for closure, it is stated that rehabilitation options as well as continuous monitoring of the environmental landscape of the footprint should be some of the activities that need to be performed. Additionally, stages to optimise rehabilitation are presented (Figure 5.1), which reiterate the inclusion of rehabilitation considerations before project development, as well as performing ongoing assessments on the land to determine whether the project objectives have been successful. Central to the theme of planning, is also research that should be undertaken prior to project development to obtain baseline conditions. Research should also persist throughout the mine lifecycle as such a platform is able to capture changes with time and thus such changes are included when reviews to closure plans are undertaken.

<table>
<thead>
<tr>
<th>Mine closure objectives</th>
<th>Mine closure planning</th>
<th>Optimising rehabilitation planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Future public health and safety</td>
<td>Closure options study</td>
<td>Planning stage: integration of mine plan with mine rehabilitation plan</td>
</tr>
<tr>
<td>Conservation of environmental resources</td>
<td>Stakeholder engagement</td>
<td>Operational stage: trial experiments and programme enhancement</td>
</tr>
<tr>
<td>Post mine closure land use is sustainable</td>
<td>Closure objectives statement</td>
<td>Active care stage: pursue rehabilitation</td>
</tr>
<tr>
<td>Minimise socio-economic impacts and maximise benefits</td>
<td>Closure cost estimates</td>
<td>Passive care stage: monitoring and management of landscape</td>
</tr>
<tr>
<td></td>
<td>Baseline studies and trial experiments</td>
<td></td>
</tr>
</tbody>
</table>
Figure 5.1: Methodological framework to follow in deriving mine closure objectives which harness the development of a closure plan and rehabilitation planning within the closure plan as presented by the MMSD (Adapted from Van Zyl et al., 2002b).

It is also important to note that this working paper does mention climate change in discussing specific mine closure approaches. Van Zyl et al. (2002b) hone in on the consideration of extreme conditions especially in environmental planning. Although mine planning designs do make provisions for precipitation frequencies of 100 year storms, Van Zyl et al. (2002b) acknowledge that this may not be a true reflection in such instances where climate change is concerned. Thus, the authors affirm that mining companies may be susceptible to such a risk, more especially those that are short-lived as these use 100 year time frames which are not a true and accurate representation of the current and future conditions.

**International Council on Mining and Metals (ICMM)**

The ICMM, in the year 2008, published a document titled “Planning for Integrated Mine Closure” which essentially is a supporting document for both professionals and specialists to employ throughout the mine lifecycle thus instilling holistic closure planning (ICMM, 2008). This document clearly presents a framework that merges closure planning with the entire mine lifecycle, to ensure that closure is considered from the inception of the project and subsequently mine planning is initiated with closure in mind. This additionally sets the boundaries in which mine development and the entire mine operations can function within. Such a strategy builds credibility, strengthens partnerships with stakeholders (including local communities) as well as facilitates sustainable rehabilitation programmes.

Within the report, the ICMM has highlighted key rehabilitation strategies to be adopted when closure plans are still being conceptualised and are further detailed on, both prior to and during mine operations, respectively (Figure 5.2 and Figure 5.3). Among the six components that are presented for conceptual planning, rehabilitation is referred to approximately eight times (Figure 5.2). Importantly, within the risks that are emphasised, natural environmental risk is the second highest priority preceded by health and safety risk. Although not explicitly outlined, rehabilitation plays a vital role in minimising and eliminating natural environmental risks. Additionally, baseline studies by specialists are used to gather contextual information which includes biodiversity assessments as well as other landscape functionality elements. The targets and goals of closure are dedicated to minimising environmental liabilities,
explicitly defining the rehabilitation outcome, and embarking on continuous communication assemblies with stakeholders to further establish their needs. Following the targets and goals, monitoring and evaluation strategies are developed followed by the process of updating the closure plan as well as placing costs estimates (Figure 5.2).
Figure 5.2: Framework by the ICMM on conceptual closure planning during the exploration, pre-feasibility, feasibility, construction and operations phases of the mine lifecycle together with the rehabilitation consideration during this stage (adapted from ICMM, 2008).

Subsequent to the conceptual planning process, a detailed design should be created during the operational phase of the mine lifecycle (Figure 5.2). This stage of the planning process takes more active approaches towards closure planning. More stringent and refined environmental goals are developed which include biodiversity conservation and rehabilitation planning. The ICMM recommends the use of domain models which are a system where closure goals for a particular element are formulated together with aerial view photographs which act as central areas of target for the action plan. Since the mine is at the operational phase of the lifecycle, the risks are reviewed again and are consequently revised appropriately and aligned with rehabilitation plans that will reduce the risks. Such risks may be those of acid mine drainage, soil erosion etc. During the operational phase, trial rehabilitation designs are initiated to further optimise rehabilitation. Where it is possible, concurrent rehabilitation commences using the trial runs that have been a success.
Figure 5.3: Framework by the ICMM on detailed closure planning during the operational phase of the mine lifecycle showing the rehabilitation considerations that come into effect at this stage (adapted from ICMM, 2008).

However, having identified the recommended closure planning process detailed by the ICMM it is important to note that there was no explicit mention of climate change within this document. There were statements that alluded to the consideration of climate change such as in the “Way Forward segment” where the Chief Operation Officer mentions that closure planners should account for environmental parameters that are expected to change over generations. Nevertheless, other documents such as ICMM (2006) do mention climate related considerations; firstly in climate regulation to maintain ecosystem processes and to ensure that vegetation thrives, and secondly in presenting climate change as a non-mining-related threat that should be assessed for rehabilitation sustainability. This document also values the baseline studies that need to be carried out to understand the climatic system of the site additionally equipping the rehabilitation team with appropriate environmental characteristics for sustainable rehabilitation. Finally, the document takes into consideration that land characteristics such as chemical composition, slope angle and physical composition, both at baseline and in the future, need to
be known to further establish a successful rehabilitation programme. Numerous other key rehabilitation constituents were highlighted in this document (Figure 5.4).

![Diagram of rehabilitation planning and implementation]

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**Figure 5.4: Framework by the ICMM on rehabilitation planning and implementation at the project development, operations, closure and post-closure phases of the mine lifecycle (adapted from ICMM, 2006).**

**Interstate Technology and Regulatory Council (ITRC)**

The ITRC documents detail the different rehabilitation strategies that can be employed for contaminated mine sites. These especially pertain to phytotechnologies which are essentially the use of natural vegetation to remediate contaminated soils. As can be seen (Figure 5.5), a process is followed in first characterising the rehabilitation programme which consists of five stages carried out from when the project is developed. The ITRC also places much emphasis on investigating three components (soil conditions, climatic conditions and existing vegetation) to further determine which phytotechnology methodology to follow.

It is imperative to note that, at the centre of identifying a phytotechnology, climatic conditions determine to a great extent the entire success of the programme. According to research produced by the ITRC (2009), climatic conditions such as precipitation, humidity, solar radiation, wind speed, rain interception capacity etc. individually have significant effects on both the substrate and the vegetation. Thus, the cumulative impacts of the aforementioned conditions potentially result in greater implications.
Additionally, climatic conditions are also used in identifying the most resilient vegetation, the plant density when planting, how often the sites need to be managed, the irrigation quantity etc. (Figure 5.5). From the findings presented by the ITRC, it is clear that climatic conditions play a vital role in establishing good phytotechnologies as well as ensuring that such technologies meet their objective of creating a sustainable land use.

**Figure 5.5:** Methodological framework and assessment tools to determine the most optimal and appropriate rehabilitation strategy in contaminated lands, as presented by the ITRC (Adapted from ITRC 2009).

**Local context**

*NEMA, MPRDA and NWA*

The South African legislation that was reviewed was the National Environmental Management Act (NEMA) (Act No. 107 of 1998), the Minerals and Petroleum Resources Development Act (MPRDA)
(Act No. 28 of 2002) as well as the National Water Act (NWA) (Act No. 36 of 1998). These address issues of general environmental management within the mining industry and more especially contamination and rehabilitation issues.

The South African legislation clearly stipulates that good environmental practices are required especially within the mine and minerals sector where land degradation is rife. Additionally, NEMA provides well ranging tasks for the sector spanning from physical care of the environment, to having the appropriate management plans in place to additionally providing financially for land remediation (Figure 5.6). The MPRDA further stipulates that financial provisions should be in place for rehabilitation, to further ensure sustainability practices post closure (Figure 5.6). Mining companies are also obligated to rehabilitate the land that they have mined in accordance with integrated environmental management as per the MPRDA and NEMA. The NWA addresses issues specifically pertaining to water (Figure 5.6: South African government legislation requirements for the environment and subsequent management, which are: the National Environmental Management Act (NEMA) (Act No. 107 of 1998), the Minerals and Petroleum Resources Development Act (MPRDA) (Act No. 28 of 2002) as well as the National Water Act (NWA) (Act No. 36 of 1998)). The main aim and emphasis of the Act is to prevent pollution (pollution defined as matter of physical, chemical and/or biological origin) and protect water resources of the country. The Act also states that the polluter to should pay for the consequences.

All these Acts tackle issues that may arise during the entire mine lifecycle; however, more attention was paid to post closure and rehabilitation phases of the mine lifecycle. The legislation does provide detailed outlines further supported by regulations for each of the investigated acts.

The NEMA addresses environmental rehabilitation in section 24 as well as in section 28. Within these sections, the Act stipulates that environmental impacts should be dealt with accordingly and that failure to do so will result in financial liability (Figure 5.6: South African government legislation requirements for the environment and subsequent management, which are: the National Environmental Management Act (NEMA) (Act No. 107 of 1998), the Minerals and Petroleum Resources Development
Act (MPRDA) (Act No. 28 of 2002) as well as the National Water Act (NWA) (Act No. 36 of 1998). Additionally, the ACT also requires that mining companies have a financial provision for closure.

The MPRDA mentions requirements for rehabilitation in sections 18, 24, 31, 39, 41 and 81. Within these sections, considerations of rehabilitation are required to be taken as the beginning of the mine lifecycle where mining companies are required to present a rehabilitation plan when applying for prospecting, exploring and/or mining rights (Figure 5.6). Additionally, the act states that approval of an environmental management plan is granted upon the mine showing the ability and capacity to remediate the land (Figure 5.6: South African government legislation requirements for the environment and subsequent management, which are: the National Environmental Management Act (NEMA) (Act No. 107 of 1998), the Minerals and Petroleum Resources Development Act (MPRDA) (Act No. 28 of 2002) as well as the National Water Act (NWA) (Act No. 36 of 1998).)

The NWA mentions requirements for maintaining good water quality and quantity in sections 1, 2, 19, 29, 49 and 137. The Act provides requirements for the land owner to ensure that water sources are not polluted and where pollution does occur, it is the responsibility of the land owner to remediate the water (Figure 5.6). Furthermore the Act states that there will be financial liability for persons that fail to take action where water has been polluted.


**Figure 5.6:** South African government legislation requirements for the environment and subsequent management, which are: the National Environmental Management Act (NEMA) (Act No. 107 of 1998), the Minerals and Petroleum Resources Development Act (MPRDA) (Act No. 28 of 2002) as well as the National Water Act (NWA) (Act No. 36 of 1998).

**South African Chamber of Mines (CoM)**

The South African Chamber of Mines released Guidelines for the Rehabilitation of Mined Land.

The Chamber defines effective rehabilitation as being sustainable in the long term without having to place extra effort in the management of the land. It then provides the key elements that should be considered for effective rehabilitation (Figure 5.7). It mentions strategies and measures that should be taken during the planning process, the implementation process as well as the legal requirements to fulfil.

Additionally, it highlights how climate considerations are vital during the planting stage as well as in seed
establishment. Furthermore, it underlines environmental characteristics that could possibly affect the success of the program such as erosion, poor soil quality and loss of biodiversity. Overall the guidelines provide a technical structure in which mine rehabilitation should pursue which is in line with international standards such as those of the ICMM and the International Union for Conservation of Nature (IUCN).

Figure 5.7: Brief outline of guidelines as compiled by the Chamber of Mines (CoM) of South Africa in their Guidelines for Rehabilitation of Mined Land document published in 2007.

**National Climate Change Response Policy (NCCRP)**

The South African government in 2011 presented its vision and plans for climate change. This came after many meetings held by different stakeholders in the years preceding 2011. The main objectives of the policy are to firstly manage climate change impacts in the social, economic and environmental spheres of the country and, to secondly ensure that the country contributes positively to
reducing carbon emissions. Among many of the topics discussed in the policy, focus is placed on adaptation; mitigation and managing response measures (Figure 5.8).

Adaptation plans focus on improving ecosystem resilience and rehabilitating areas that will provide resilience to physical climate change impacts. The mitigation segment refers to the mining industry numerous times; however, this is in relation to the industry being one of the most carbon intensive in the country and the need to assess such industries while reducing any economic risks. The management of response measures highlights how the country will aim to reduce carbon emissions, reduce economic risks while exploiting all opportunities that may arise. The policy also highlights that water scarcity issues will be one of the major physical impacts for industries.

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**Figure 5.8: South African government plans regarding climate change as from 2011.**

*Mining and Biodiversity Guideline: Mainstreaming biodiversity into the mining sector*

The guidelines mention that biodiversity conservation is more likely to assist in enhancing adaptation and improving resilience to climate change. Effective ecosystem functioning is seen to be a method that will assist with risk reduction to climate change impacts (DEA *et al.* 2013). The guidelines
also note that climate change trends may present an additional impact which may likely influence the significance of the impacts on ecosystem services.

The guidelines also highlight that rehabilitation of disturbed land should be conducted as a third level strategy after the mining company has best attempted to best avoid the disturbance, and in instances where disturbances are inevitable has tried to minimise resulting impacts. The guidelines then present six principles for good decision making (Figure 5.9) detailing out consideration that should be taken by mining companies during decommissioning and closure phases. The final principle on effective implementation and adaptive management highlights that rehabilitation success may be influenced by climatic conditions, and thus mining companies are encouraged to conduct performance monitoring and adaptive management.

**Apply the law:** mining right holder is responsible for any environmental liability. Mining companies should then be aware of degradation resulting from operations.

**Use best available biodiversity information:** Updated biodiversity information to be used to inform closure plan. Mining companies should involve biodiversity specialist in designing mine waste dumps, TSFs, water management structures and surface topography.

**Engage stakeholders:** Engage stakeholders on biodiversity and closure plans. Mining companies should explore opportunities for collaboration, partnerships, and for local communities to benefit.

**Use best practice in EIA to identify impacts:** Environmental Management Plans (EMPs) should present mitigation and management options for impacts. There is also a need for more detailed assessments of unforeseen residual or latent impacts. Mining companies have the duty to address environmental liabilities, risks, pollution and ecological degradation.

**Apply mitigation hierarchy in a robust EMP:** All necessary actions to prevent or remediate pollution and mitigate impacts on biodiversity and ecosystem services must be implemented prior to or during closure. Mining companies should ensure that mitigation can be effectively undertaken and that a risk-averse approach is taken in dealing with residual negative impacts.

**Ensure effective implementation and adaptive management:** The success of rehabilitation may vary, influenced by climatic conditions, the type of biodiversity impacted, uncertainty about natural succession processes and technical or other capacity limitations. Mining companies should conduct performance monitoring and adaptive management to meet rehabilitation and closure objectives is required by legislation.

Figure 5.9 Principles highlighting good decision making for mine decommissioning and closure.
5.3 Summary
Collectively, these guidelines, standards and legislative requirements are used as tools within the mining sector to facilitate sustainable closure and rehabilitation. The time frames ranged from 1998 to 2013 (Figure 5.10). Furthermore, noncompliance, especially with legislative requirements, results in penalties and in serious cases, imprisonment. The presented documents show varying levels of detail depending on their target and key aim in formation. Thus, ideally these documents, together with others that were not mentioned here, are used collaboratively for optimal results. Research documents such as that prepared by the ITRC shows exceptionally more detail in rehabilitation components as compared to governmental documents such as the South African legislation which consisted of more superficial contexts further allowing interpretations. Holistically, it can be seen that all the documents presented are ideally aiming for a final land use that is synonymous to sustainable development in both the short and long term. In some documents it is more articulated than in others. Finally, the research question that was posed was what do international and local guidelines on post closure practices state about climate change considerations? From the investigated documents, climate change considerations are most explicitly discussed in the international documents as opposed to the local documents although the Mining and Biodiversity guideline does mention climate change on a high level. Local documents do however place all responsibility of the owner/right holder to ensure that all rehabilitation aspects are considered. And thus, it may be deduced that South African legislation is expecting mining companies to make well informed decisions that will ensure successful rehabilitation. Importantly, the South African government only presented a climate change policy in 2011; years after legislation on mine closure had been promulgated. It is therefore expected that the legislation reviewed lacks some detail on climate change.

Figure 5.10: Time frames for the publication of the ten documents analysed.
Chapter 6

6 Climate change and rehabilitation disclosure in SD reports

6.1 Introduction
Thus far, it has been identified from the first objective that mining regions will be affected by climate change impacts such as temperature rise, varying rainfall patterns, decreased soil moisture as well as cumulative effects resulting in biome shifts (Chapter 4). The second objective then highlighted expectations in both the international and local arena on post closure and rehabilitation practices (Chapter 5).

In efforts to contextualize this chapter, one has to comprehend the aim of the study with the specific objective being addressed. The aim of the study is to investigate whether mining companies that are operating in South Africa have given climate change impacts a considerable thought at the post closure stage, especially in rehabilitation planning and roll out of projects; additionally the specific objective that will assist to fulfil this aim is to investigate, by reviewing documents, whether companies operating in South Africa have considered the impacts of climate change at the rehabilitation phase.

This chapter will thus address the third objective of the study. The third objective was addressed using two different sources of data (Chapter 3). This chapter is dedicated at critically analysing SD reports, and other equivalents, from the identified companies, thus addressing part of the third objective. As has been briefly introduced in Chapter 3, a purposive sample was used to abstract qualitative interpretive content analyses from the documents. According to the GRI, SD Reports contain supplementary information on rehabilitation in addition to climate change related information, when compared to the Annual Reports and Integrated Reports. To additionally emphasise, this section is only targeted at publicly available documents which are also documents that investors, communities and other stakeholders have at their disposal to gain a better understanding of the company.

The reports were analysed in a soft copy format to allow for straightforward and convenient computational conversion as well as to eliminate any human errors that may occur. Printed versions of the documents were avoided in order to minimise paper consumption. Thus, the process of critical
analysis involved tools in Adobe Reader XI which were search, highlight text, selective text, comment and recall text.

A total of 50 documents were analysed, for the years 2011, 2012 and 2013 for a total of 17 mining companies. These consisted of 37 SD Reports, 3 Annual Reports as well as 10 Integrated Reports. One company was still a subsidiary in the year 2011 and thus reported under the holding company; in 2012 and 2013 the company produced an Annual Report and an SD Report, respectively; hence the total of 50 and not 51.

This chapter will start off by presenting an overarching view of what the SD Reports enclosed. Following this, each company’s highlights and achievements will be stated which is to be read in conjunction with Appendix 6. Finally, a summary will be presented which will also contextualize the findings of this chapter within the entire research.

6.2 Key findings
To start off on a positive and well-rounded note, all companies mentioned climate change in a minimum of two of their SD reports (or reports equivalent to these). However, most mentions of climate change were from associated and anticipated costs pertaining to energy and carbon emissions as well as availability of water. And thus, as suspected, majority of the companies are imbalanced in terms of highly prioritising their impacts, contribution and effect on climate change and consequently not considering how climate change may possible affect them in return. Throughout the documents a more reactive strategy is employed in terms of mitigating climate change contributions. Consequently, this has sidelined the proactive approach of preparing businesses for climate change especially for the rehabilitation of mined lands.

Companies are definitely approaching climate change issues from a risk based approach and are additionally incorporating the overall climate change risk within their core business operations. However, this in many cases - as will be seen below- is in relation to energy concerns at the operational phase.

The following sections will provide an assessment of SD reports for each of the 17 mining companies, described in both paragraphs as well as in highlighted points in Appendix 6.
Table 6-1: A summary of the consideration of climate change during mine rehabilitation by 12 mining companies listed on the JCE SRI Index in the year 2013.

<table>
<thead>
<tr>
<th>Company name</th>
<th>Consideration of climate change impacts</th>
<th>Climate change impacts on rehabilitation</th>
<th>Comments and notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>YES NO</td>
<td>YES NO</td>
<td></td>
</tr>
<tr>
<td>African Rainbow Minerals</td>
<td>YES NO</td>
<td>YES NO</td>
<td></td>
</tr>
<tr>
<td>Anglo American Platinum</td>
<td>YES NO</td>
<td>YES NO</td>
<td></td>
</tr>
<tr>
<td>Anglo Gold Ashanti</td>
<td>YES NO</td>
<td>YES NO</td>
<td></td>
</tr>
<tr>
<td>BHP Billiton</td>
<td>YES NO</td>
<td>YES NO</td>
<td></td>
</tr>
<tr>
<td>DeBeers</td>
<td>YES NO</td>
<td>YES NO</td>
<td></td>
</tr>
<tr>
<td>DRD Gold</td>
<td>YES NO</td>
<td>YES NO</td>
<td></td>
</tr>
<tr>
<td>Exxaro</td>
<td>YES NO</td>
<td>YES NO</td>
<td>Identification of increasing rehabilitation costs due to droughts</td>
</tr>
<tr>
<td>Gold Fields</td>
<td>YES NO</td>
<td>YES NO</td>
<td></td>
</tr>
<tr>
<td>Harmony Gold</td>
<td>YES NO</td>
<td>YES NO</td>
<td>Considering climate change in rehabilitation planning</td>
</tr>
<tr>
<td>Impala Platinum</td>
<td>YES NO</td>
<td>YES NO</td>
<td></td>
</tr>
<tr>
<td>Kumba Iron Ore</td>
<td>YES NO</td>
<td>YES NO</td>
<td></td>
</tr>
<tr>
<td>Lonmin</td>
<td>YES NO</td>
<td>YES NO</td>
<td></td>
</tr>
<tr>
<td>Northam Platinum</td>
<td>YES NO</td>
<td>YES NO</td>
<td></td>
</tr>
<tr>
<td>Royal Bafokeng Platinum</td>
<td>YES NO</td>
<td>YES NO</td>
<td></td>
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<tr>
<td>Sasol</td>
<td>YES NO</td>
<td>YES NO</td>
<td></td>
</tr>
<tr>
<td>Sibanye Gold</td>
<td>YES NO</td>
<td>YES NO</td>
<td></td>
</tr>
</tbody>
</table>

Reports from Exxaro

Not only the climate change risks associated with energy were acknowledged, but also those that are associated with the physical impacts such as floods. Climate change was considered to be one of the major sustainability issues within the company’s business environment. In addition to this, the company researched which climate change impacts were most likely to affect the regions in which they are operating in. With the findings of the research, Exxaro aimed to reduce GHG emissions while increasing energy efficiency and has partnered and ventured into the renewable energy sector in order to reduce GHG emissions. Exxaro aims to rehabilitate the land that has been disturbed by their operations in order to meet their sustainability goals.
The company has also invested much time in identifying the risks associated with mine rehabilitation where the Key Performance Indicators (KPIs) were provided. Having said this, none of the risks identified were related to climate change; majority of the risks were those associated with the quality of EMPs. The company acknowledged the mining industry in general faces numerous challenges in the environmental sphere especially in matters of water security, climate change and legislative requirements. In stipulating the climate change risks that the company is susceptible to, the report mentioned that droughts could further cause problems with rehabilitation where costs are expected to increase. Having conducted a climate change study as reported in 2011, Exxaro started devising mitigation and adaptation strategies for regions that are prone to increased storm events. Overall, the reports broadened the scope in which the topic of climate change was covered.

**Reports for Harmony Gold**

The company acknowledges that taking adaptation and mitigation strategies currently will give it a competitive edge when carbon emission costs are implemented and thus all their current projects whether on the greenfields or brownfields are considering climate change in their design. The company has made a clear link between climate change and rehabilitation where the company foresees that events such as flooding and inadequate water supplies could affect both their operation and their rehabilitation roll-out. Interestingly, although the company has gone through the effort of identifying how much contamination exists in the areas they operate in, they have not accounted for this in their financial statements as there has not been a quantifiable measure to align it to. The company is promoting a spirit of collaboration with the surrounding mining companies to deal effectively with the contaminated water in the area.

As part of the company’s sustainability strategy, it focuses on environmental and societal problems where climate change is mentioned as one of the areas to consider during the planning and designing process to further ensure resilience in the future. The company, having developed a climate change and energy efficiency policy is focusing in areas around energy efficiency, technological innovations and adaptation and mitigation measures. The company clearly states objectives that need to be addressed before and during the next financial year which are linked to environmental performance.
The company has embarked on a quantification study to address which physical impacts of climate change are they susceptible to; this contained a weather risk assessment. The company places great emphasis on collaborating with the community before and during rehabilitation and also developing comprehensive plans to deal with climate change. The report is also prepared in line with the GRI guidelines specifically designed for the mining and mineral sector. At the end of the report, the company does state that it is not able to report fully on climate change impacts as many are not or have not been quantified and thus climate change is widely integrated into the entire business risk process.

6.3 Summary
Firstly, of the 50 reviewed documents, only 2 had not self-declared the application of GRI guidelines, where almost half of the reviewed reports had self-declared a GRI G3 A+ application level (Table 6-1). Overall, as already highlighted in Table 6-1, all companies mentioned (directly and indirectly) climate change considerations. However, most of these were pertaining to energy, GHG emissions as well as to water availability. In most cases, it appeared as though climate change impacts that directly impact on current operations are highly prioritised; such as the availability and the cost of energy, the availability of water as well as the introduction of the carbon tax policy which will have some financial implications. Only two out of the 17 companies have reported that they have considered climate change at rehabilitation (Exxaro, Harmony Gold). These were due to impacts such as droughts and floods. The companies were able to associate rehabilitation after extensive studies were undertaken to determine what impacts should be anticipated.

The most common concern that arose was various instances where companies had identified climate change impacts but still failed to develop appropriate response strategies. Some companies had identified floods as a future risk; however, the slope design of the TSF was not changed to accommodate this as such requirements are said to be not legislated yet. Another concern was that companies which were already experiencing significant climate variabilities were still not taking measures in response. An example of this is with Royal Bafokeng Platinum and DRD Gold where flooding hindered rehabilitation but there were no mentions of how rehabilitation planning will further account for such flood events. There is a gap that exists requiring a further application of knowledge. Cases show that companies are
able to respond better to impacts that affect their operations directly as opposed to rehabilitation. Importantly, the investigated companies were affiliates, members, and or complied with some of the following: GRI, ICMM, CDP, Nedbank Green Index, EITI, UNGC, WBCSD, CSI, NBI, IR, CoM and IR.

One of the major highlights were the numerous uncertainties due to the lack of a single body that hosted comprehensive data to further identify what impacts are applicable to the business. Thus companies find themselves not knowing what to expect, or alternatively for those that do have the impacts at their disposal, they are uncertain on how to address the issue. However, an opportunity that was identified was that companies are working with consultants and University institutions on rehabilitation research as well as in obtaining climate change data, which shows some level of willingness to collaborate with other stakeholders.
Chapter 7

7 Climate change and rehabilitation considerations: personal interviews

7.1 Introduction

Having seen from the previous chapter (Chapter 6) that only two companies had considered climate change during the rehabilitation process; reasons can only be postulated to further explain this trend. As mentioned in Chapter 3, document analysis, although it provides substantially analytical information captured in a specific time frame, its gross limitation is that one cannot interrogate the findings further. Therefore, to further address the third objective, a different supporting data sourcing was implemented. This consisted of interviews with not only mining companies but also consulting firms as well as academic institutions. Interviews additionally are able to highlight and provide underlying reasons through deeper probing. Although this research was specifically aimed at the rehabilitation phase of the mine lifecycle, it was also of good research methodology to slightly broaden the scope to the other phases of the mine-lifecycle to further establish where climate change is being of concern since it currently appears as though it is not at the rehabilitation phase.

A total of 12 interviews were conducted with mining companies, consulting firms as well as academic institutions. These consisted of five mining companies, five consulting firm divisions and also two academic institutions. In some consulting firms more than one interview was conducted where in each of the referred to divisions elaborated more or alternatively highlighted different aspects on the subject.

7.2 Key findings

Mining companies

Theme 1: Rehabilitation programmes

Of the interviewed participants, 60% revealed that due to the nature of mining the respective commodity, there were relatively high levels of toxic contamination as a byproduct; whereas the other 40% of participants stated that their mining activity results in little to no toxic contaminants (Figure 7.1). As a result of the toxic contaminants, the companies further disclosed that the toxic product was subject to treatment prior to it being exposed to the natural environment. Additionally, it is also important to note
that even for the companies that do not produce high levels of contaminants, there are efforts and programmes to address the degradation which results generally in the mining industry.

Figure 7.1: Responses on the nature of mining activity, especially the toxic contamination present.

The dominant sources used to obtain information for rehabilitation were from baseline conditions, from specialist studies as well as using rehabilitation standards (Error! Reference source not found.). These sources of information consist of and further elaborate on soil characteristics, biodiversity, indigenous species, social context, the mine fit into the ecosystem, pre-mining land use, standard conditions to further research on, rehabilitation structure as well as any signs of land subsidence. Rehabilitation is then planned in accordance with the findings from these three main sources. When a rehabilitation plan has been developed, the appropriate financial provision is set aside and such programmes and cost estimations are reviewed annually at minimum in most cases.

Figure 7.2: Sources of information required for rehabilitation planning.

Theme 2: Climate change awareness
When asked whether the company has any knowledge on climate change and the recent predictions all interviewed participants revealed that the companies have knowledge about climate
change. The knowledge areas within climate change straddled across financial implication to environmental implications and also to topics of research and development (Figure 7.3). However, with these knowledge areas being stated, it was additionally identified that all mining companies expressed deep levels of uncertainty with regional physical environmental impacts. Although some had started conducting studies to further enlighten what is to be expected, a general consensus was that there is still some uncertainty. As can be seen (Figure 7.3) there are generally more environmental implications that are known. Participants explained the potential risks from the financial implications as well as the importance of institutions such as the CSIR and IPCC in research and development within the climate change environment. Additionally, all the mining companies accepted the findings presented by both international organisations and local research institutions. As will be seen in the following sections and also slightly alluded to in Chapter 6, financial implications for the sector will prove to be tremendous should companies not start taking precautionary measures at present.

Figure 7.3: Three main areas of knowledge within the climate change sphere.

All companies were very much aware of business risks that had already arisen as well as those that are anticipated. These can be classified as either upside risks, or downside risks. The downside risks were split among the financial, manufactures and the environmental capitals (Figure 7.4). The companies expressed that there could be financial losses due to carbon trading and the carbon tax policies that are imminent. These would be as a result of the company not being able to reduce its GHG emissions to a
legally acceptable level. Additionally, such reductions mechanisms were also said to be expensive to implement but do however provide long term benefits. Cooling costs were also a concern since increased surface temperatures may have impacts on underground cooling requirements. It was with the exception of one company which had not considered climate change impacts further beyond the carbon tax policy as this was thought to be of the highest significance. Threats posed to the manufacturing capital were those of the infrastructure on the surface which includes TSFs and nearing dams which could overflow or alternatively dry up. The environmental capital received the highest number of risks which concerned water scarcity, extreme weather conditions, vegetation growth and sea level rise. Vegetation growth posed a risk to one of the companies as it relied on a particular species in its supply chain and thus growth would affect the business operations. One participant did state that the company in general is not taking enough measures to address the risks, more could be done.

The potential opportunities that the companies associated climate change with ranged between the financial and environmental capital. Some companies expressed that a new market demand would arise due to the promotion of energy options that do not release a substantial amount of GHGs. Within the environmental capital, higher precipitation levels were associated with water security in regions that are currently water insecure. Additionally, the technology of carbon capture and storage (CCS) is potentially an opportunity of reducing the atmospheric GHGs.

Following the risks (both downside and upside) that the companies had mentioned, it transpired that 40 % of the companies feel that climate change will affect the company negatively while 60 % felt that the effect would be both positive and negative (Figure 7.4). It can be deduced that none of the interviewed companies see climate change as an occurrence bearing only positive outcomes.
Figure 7.4: Business risks that have arisen due to climate change.
Figure 7.5: Overall effect that climate change will have on the mining companies.

Since it had been established that climate change poses many risks to the business operations of the company, it was then enquired whether any mitigation and/or adaptation measures had been developed in response to the risks identified (Figure 7.6). Approximately 40% of the companies’ had no direct mitigation or adaptation measure in places, and 60% of the companies did have measures in place. Of those that did not have any direct measures, this was due to the fact that the measures were being implemented for other reasons, predominantly financial, as opposed to climate change reasons. Some of the mentioned measures were the development of mechanisms that reduce the reliance on coal generated energy, the increased efficiency of energy as well as strategies to address water management.

Following the understanding that some companies had mitigation and/or adaptation measures in place, the next inquiry was as to what are the potential gains could the company incur as a result. The responses to this inquiry spanned across all five of the capitals; which are: financial, manufactured, social, human as well as environmental (Figure 7.7). Financial gains would be both direct where the company is awarded a cash prize or cash incentive and also indirect such as cost reduction as a result of energy efficiency. The manufactured capital gains are increased business efficiency due to the optimisation of operations, assets protection as well as reducing future risks and uncertainties. These gains will ultimately maintain a sustainable business. The social and human
Figure 7.6: Mitigation and/or adaptation measures developed in light of climate change.

Figure 7.7: Potential gains for the mining companies
capitals also contributed to running a sustainable business by obtaining a social license to operate, protecting the interests of the surrounding communities and also promoting good health by not contaminating the ambient air. The environmental gains would be the overall reduction of the use of non-renewable resource (coal) as well as conserving energy where this could subsequently be shared with the community.

Thus far, companies had not explicitly made a connection between climate change and rehabilitation planning. Therefore, the participants were asked whether the current rehabilitation programmes are at risk of being impacted by climate change. The responses were varying as follows; 20% responded no, 40% responded yes and 40% responded partially yes (Figure 7.8). For the 20% that responded no, the reason was that climate change will occur gradually and thus rehabilitation programmes will be able to adapt like all other vegetation. This reasoning was based on a premise that rehabilitation programmes are to establish a self-sustaining ecosystem that is resilient and thus such a system would be able to adapt to gradual changes. For the companies who responded by being slightly inclined to agreeing still had reservations as there were still uncertainties in climate change models and as a result, there was still ongoing research on the regional anticipated changes as well as how these would affect vegetation. The participants that responded by agreeing fully that rehabilitation would be affected by climate change, were basing their reasoning on the longer lived mines and also in relation to the changing rainfall patterns. There was a concern that TSFs may spill or alternatively not be able to withstand the extreme precipitation and would subsequently collapse.

In probing whether climate change would affect the types of covers and species used for rehabilitation as well as the slimes dam capacity; the responses were no, yes and probably no for 40%, 40% and 20% of the companies, respectively. The 20% that responded probably not, stated that most research that was being done was strictly aimed at understanding the water issues that may affect the business. The 40% that responded with a no, further reiterated that the changes anticipated are gradual and thus will not affect rehabilitation significantly. The remaining 40% that responded by saying yes climate change has been considered in rehabilitation covers, based their response on the
reasoning that climate change will affect the long lived mines and also on current research being carried out on vegetation tolerance to drought conditions.

Figure 7.8: The effect that climate change will have on the current rehabilitation programmes.

Figure 7.9: Considerations of climate change in cover type, rehabilitation species and slime dam capacity.
Lastly, the questionnaire attempted to establish whether climate change impacts were included in the EIA processes of the company at any phase of the mine lifecycle. A total of 40% responded negatively and 60% responded positively (Figure 7.10). For the 60% positive responses, companies had developed climate change impact assessments that need to be carried out by each mine in addition to the general EIA as well as by ensuring that all specialists’ studies attempt to consider future impacts. The 40% negative responses reasoned by saying that legislation does not require such as well as due to the fact that no recent EIAs have been carried out; however, future EIAs will consider climate change to some degree.

![Climate change and Environmental Impacts Assessments (EIAs)](image)

**Figure 7.10:** Climate change incorporation in the EIA process.
Consulting firms

*Theme 1: Views of mining companies/clients*

Consulting firms were interviewed not only to obtain a general view of what the mining industry thinks about climate change, but to also establish what consultants viewed as best practice as well as recommendations from a field that has worked with many sectors across the board.

Generally, the consulting firms acknowledge that most mining companies are aware of climate change as many companies are also members of international bodies which promote good environmental practices. Additionally, some companies see opportunities with climate change where projects such as those of energy efficiency can be used to reduce costs incurred while also contributing positively to the environment. However, one consultant did express that in most cases climate change is only well known by individuals who are within the environmental and or sustainability units of the company. Individuals outside these departments, although may be affected, are not likely to know, or at least are not required to know about it as part of their employment scope.

There was a split view on whether mining companies view climate change to be with a significant amount of uncertainties to not be fully proactive (Figure 7.11). One school of thought was that there is no uncertainty as the companies are using findings from the IPCC which are credible, although they are at a global level. Uncertainty was thought to be present as mining companies fail to approach environmental concerns of projects from a long term approach. Additionally, the nature of the mining industry is said to already have numerous uncertainties in terms of the market volatility. Another school of thought was that even though the company in general may accept findings as presented by the IPCC there are still some sceptical individuals within the company.

The perceived level of awareness towards the climate change by mining companies ranges from low, medium to high with a further exception of dependency. Supporting low levels of awareness was the general lack of concern seen in the mining sector. However, the medium to high awareness was supported by the fact that a vast majority of companies include climate change within their top 10 business risks especially when it comes to the carbon tax. Furthermore, several consultants highlighted that the level of awareness is a highly variable measures as it depends on the
size of the company as well as the particular department. Bigger companies were said to have a higher level of awareness due to the international and local organisations which are affiliates, as opposed to smaller companies that are not affiliated to such organisations.

Figure 7.11: Reasons for uncertainty on the climate change issue.

Unanimously, the participants concluded that there is poor awareness of climate change specifically at the rehabilitation phase of the mine lifecycle. Climate change is said to be considered to a greater extent during the feasibility phase of the life cycle. On average, the extent to which climate change was considered at rehabilitation was 3 out of 10, where this rating confirms the minor concern. However, having obtained this score, the consultants did reveal that there were efforts to improve this through research that is currently being pursued.

Areas of climate change that are given priority are the ones listed below. The list below is placed in order of most mentioned to the least mentioned. All consultants mentioned the importance of water, especially for the operational phase.

- Water
- Carbon tax
- Air quality
- GHG emissions
- Temperature
**Theme 2: Consultants views on climate change**

In addition to prioritising the impacts of climate change, the consultants all agreed that climate change will pose the highest threat to the operational phase and to a slight degree the closure phase. This was attributed to the probable impacts of climate change which are the most material issues during the operations.

Unanimously, the consultants all agreed that rehabilitation will be affected significantly by climate change. The following reasons were provided:

1. Appropriate species selection, survival and overall adaptation are influenced by climate conditions.
2. Currently, EMPs are not implemented as rigorously as they should and thus this gap will further be exacerbated if climate change is not considered.
3. Should climate change not be considered, it is likely that there will be reputational issues due to the unintended consequences.
4. Even though a functioning ecosystem is the aim of rehabilitation and thus adaptation is one of the characteristics of such a system, climate change considerations should be accounted for.

Research would thus form the appropriate bridge in between the challenges identified by both mining companies (seen in the previous sections) and consultants. Research may take numerous forms to fully achieve its goal, therefore the appropriate topics need to be selected further ensuring that misconnects and gaps are adequately addressed. The research themes proposed spanned across the climate change impacts while even also recommending a research approach such as risk assessments (Figure 7.12). Institutions that would adequately be able to champion such research were also recommended (**Error! Reference source not found.**), where Universities and credible institutions such as the CSIR and SANBI were seen to be playing a pivotal role in rehabilitation research.

Additionally, one of the participants expressed that there already is research that is currently being pursued by Universities. The only problem that exists is a level of disconnect between industry and academia. Although mining companies are also recommended to partake in this research, a concern
that was raised was that the nature of the industry seldom allows for long term research; however, this is not a factor that limits mining companies to be active players in this field.

Figure 7.12: Research themes and institutions in rehabilitation programmes.

In addition to the research opportunities that could be possible in climate change and mine rehabilitation, a further stride could be taken with formalising the findings in a policy package. The consulting companies then advised on whether policies should support the research findings. Overall, the consensus was that policies, in the form of some legislative requirements, would be appropriate in further ensuring compliance and accountability. This will additionally reduce the burden on mining companies being left to conduct business beyond the required compliance levels. There were mixed views on whether this should be within an existing documents or it should alternatively be a new document. Suggestions were that there already are numerous documents that encourage industry to develop adaptation measures such as the NCCR, therefore such documents can be further enhanced to incorporate findings of such research. However, there was a single view encouraged the mining companies to pursue the findings of the research voluntarily especially because the South African environmental legislation is already good enough. This view also supported the notion that should stricter boundaries be placed around this issue, it will become another “tick-box” exercise, which will defeat the whole purpose.
Available tools that could be used to encourage climate change impact consideration during rehabilitation included calculators for GHG emissions, critical analysis of closure and rehabilitation plans, the current legislation (NEMA, MPRDA), Australian industry principles as well as other international guidelines and best practice standards. Furthermore, EIAs and SEAs are also thought to be good tools as these are able to take into account the baseline conditions where after academic input could be used to further account for climate change.

Lastly, all interviewed consultants agreed that climate change will pose predominantly negative effects on the mining industry. Although there were some opportunities such as rising demands in a new market and the possibly reduced energy costs; the risks and costs associated (extreme events, water stress, and energy availability) were thought to far outweigh the opportunities. Additionally, it was expressed that for mining companies who have already started taking mitigation and developed adaptation measures, there will not be significant negative impacts; however, those who are delaying such activities will suffer the consequences.

**Academic institutions**

*Theme 1: Views of mining companies/clients*

Similarly to the consulting firm interviews, academic interviews were aimed at establishing how academic views the topic with respect to the mining industry and also what the views from academia are. As seen in Chapter 6, academic institutions do play a role in rehabilitation planning and therefore it fits that a view is obtained from this field which has been involved in the research component.

The general consensus was that companies operating in South Africa but that are also internationally based are more aware of climate change especially as a result of them having to comply with international bodies which provide funding. It was highlighted that the local companies show less awareness as they mostly aim to achieve the bare minimum compliance standards. However, level of awareness also varied within a company where on one hand it was highlighted that the younger managers are inclined to accept the climate change findings and potentially tackle ideas to solve the issue while on the other hand the older managers are heavily sceptical thus delaying
These aforementioned statements were supported by the reasoning that there is still uncertainty within the climate change as some available data shows inconsistencies. Furthermore it was highlighted that mining companies seek for a more engineered solution with known inputs and known outputs and the climate change discourse unfortunately does not offer such. Academic research also identifies that due to the uncertainties seen in the models, research in rehabilitation especially within arid zones of the country proves to be even more burdensome when straddling regions that are thought to receive frequent droughts as well as floods. Both participants agreed that climate change is currently not of concern at rehabilitation but more concerns are during the operational phase. The list below shows which impacts of climate change are currently of concern for mining companies:

- Water availability
- Water contamination (although not directly linked to climate change)
- Increasing temperatures

**Theme 2: Consultants views on climate change**

It was expressed that both operational and closure, especially rehabilitation, phases of the mine lifecycle are intricate in further establishing and identifying possible threats. A unanimous agreement showed that rehabilitation and restoration programs will be affected by the impacts of climate change. Climate change impacts are said to be important especially because they determine the success of the program in regions where summer and winter rainfall areas are projected to shift as well as in vegetation establishment. Furthermore, it was suggested that species selection may need to change, where vegetation that grows faster should be used further enhancing the adaptive capacity of the plant with climate change. Still on species appropriateness, it was highlighted how summer-winter rainfall gradients are vital drivers in vegetation distribution (e.g. succulents well adapted to arid zones of winter rainfall and grasslands adapted to summer rainfall regions) and thus changes in climate need to be known encourage best possible vegetation selection.

Current research was recommended to focus on two key elements (Figure 7.13). Impacts that are site specific were highlighted to play a pivotal role in establishing site specific interventions.
Furthermore biological interactions (soil and rain) were also recommended to be assessed in response to impacts especially in arid zones. Similarly to the information obtained from consulting firms, Universities as well as other well established institutions are seen to be appropriate in research execution. Additionally, collaborative efforts were encouraged through public and private partnerships which also accommodate entrepreneurs (Figure 7.13). Well established institutions such as the CSIR, ARC, SAEON could further assist in providing institutional memories through data storing as well as data sourcing.

Tools that are already available that could be used to further understand climate change impacts and ensure better accounting of the topic, were said to be the Global Climate Models (GCMs), available policies and regulations from the South African Department of Environmental Affairs, as well as scenario developments. To examine site specific progress structured monitoring could be implemented using data loggers as well as fixed photography through time. Furthermore, academic institutions do not agree that EIAs and SEAs are appropriate tools that could be used to consider climate change impacts as there are already some discrepancies with these processes. Issues highlighted with the EIA and SEA processes include: not enough time available during the processes to adequately identify and quantify possible impacts, cumulative impacts are rarely fully accounted for, and these processes are said to be too broad and also biased according to the methodology employed. Thus, these processes can only be useful in obtaining baseline data where after long term monitoring systems and central climate change bodies can continue working.
Finally, although regional effects play a role; the academic institutions explained that climate change will predominately affect the mining sector negatively, for the following reasons:

- Water availability issues are already a problem and are expected to be exacerbated,
- Increasing temperatures also pose a threat to labour relations as well as chemical processes within the production stage, and
- Other global change challenges such as an increasing population could be an additional factor on natural resources where an increased number of human dependencies on water resources could result in increasing competition between the general population and the mining sector.

### 7.3 Summary

The findings from this chapter have sufficiently elaborated specific issues, further substantiating the findings of Chapter 6. Mining companies generally show that initiatives have been taken, especially in understanding climate change risks and further developing mitigation measures. Similarly to the previous chapters, it is shown that climate change is seen to affect three areas being energy, water as well as GHG emissions. Companies appear to show a good understanding of the risks of climate change; however, these are again mostly inclined to the operational phase as a result of water issues, energy costs and GHG emissions. On a personal perspective, the interviewed participants generally did show enthusiasm and had previously attempted to champion climate change projects but due to issues such as uncertainty, their efforts have not been as fruitful as they would
have liked. Overall, more than half the companies expect climate change to affect rehabilitation especially for the longer lived mines; nonetheless, the lack of full quantification of impacts poses issues of uncertainty.

Both consultants and academic institutions shared that awareness of specific climate change issues was dependent on the size of the company as well as on the age of the individuals within the company. Academia and consultants shared similar sentiments of affirming that climate change is not currently high on the agenda when planning for rehabilitation; however, it will be a mining phase that will be significantly affected. Furthermore, a mixture of researching institutions is recommended to further ensure that the gap of uncertainty and unavailability is bridged.

A general issue that arose across all three sectors being interviewed was that uncertainty is mainly a result of data sourcing and thus mining companies are unable to quantitatively define the anticipated impacts.
Chapter 8

8 International and local examples on successes and failures

8.1 Introduction

The previous two chapters as well as Chapter 4 have shown that climate change impacts are likely to be felt in South African mining regions. Additionally, it has been highlighted that climate change response strategies have been more inclined towards mitigation efforts and thus mining companies remain vulnerable to climate change impacts, especially at the rehabilitation phase where most value has been extracted from the land. For example, the AMD seen in the Witwatersrand basin shows how problems arise decades later due to ineffective mine closure and rehabilitation in the past. However, this research is not aimed solely at highlighting the challenges in climate change and rehabilitation, but it also aims at learning from good practices using successful examples to affirm that complex situations, when approached with the appropriate manner of thinking can be resolved. Thus the fourth objective of the study is addressed in this chapter. The research question being asked here is, how has climate change been considered during the rehabilitation process of local and international companies?

Therefore, having explored and attempted to gain an understanding of what is occurring in some mining regions of South Africa, it is important that successful climate change related considerations are mentioned. The following examples are both local (South African) as well as international. International examples have been used to identify which strategic elements can be applied in the South African context, bearing in mind that different regions in the world have different influences, government systems and legal frameworks. A noteworthy point is that such examples cannot be directly mirrored onto the South African context as different regions of the world are entrenched within different policy and government structures and also the social, environmental and economic contexts vary sufficiently. Environmental research has been shown to be complex and dynamic and thus the solutions are not simply a “one-size fits all” product (Levine and Renelt 1992; Stern et al. 1996; Ashley and Boyd 2006; Roudgarmi 2011). Thus, precaution was taken in these case studies. However, a countering effect is that most of the investigated mining participants are
internationally based and although they are exposed to a different political atmosphere in South Africa, some measures taken within the South African context would only mean good business practice and compliance with other numerous voluntary standards.

8.2 Key findings

International case studies

*Case 1: Glencore in Sudburg, Ontario, Canada (2014) – Climate Change Planning.*

Adapted from FBC and Mirarco (2014)

Overall, Glencore is driven by a strong desire to understand the local climate risks. The company initiated the Climate Change Planning Project to address challenges arising due to climate change within all their core business operations. The aim was to identify the climate risks and further develop strategies to manage such risks. The purpose of the case study was to firstly, understand how Glencore has planned to manage negative climate change impacts; secondly, to identify the processes that have already been undertaken, and lastly, to provide a way forward in terms of adaptation. Risks in general are seen as hindering factors preventing the business from making the desired revenues. The company is further motivated as intensification of both weather and climate events have been identified.

A climate risk assessment was conducted at Glencore to identify and understand which impacts are highly likely and which of these impacts the company is vulnerable to. The climate risk assessment involves three areas which are; physical climate change impacts, GHG emissions as well as energy. All three of these components address different risk within the business, all stemming from climate change. For the physical climate change component, the company assesses the physical risks, adaptive capacity as well as technology available. For the GHG emissions component, the company assesses the Cap & Trade market and also the technology available to mitigate emissions. Finally, the energy component consists of efficiency analyses, costs associated as well as the technology in place to reduce energy consumption.

The study then identifies climate and weather related risks based on past and future events that the company was and will be vulnerable to. The risk assessment identifies four major physical
impacts that have previously affected the company. These are; i) seasonal variability (less predictable weather patterns), ii) flooding (cumulative impacts), iii) increased freeze-thaw cycles, and iv) increased number of hot days. Seasonal variability has become common and thus the company finds it difficult to protect their operations. Prolonged rainfalls in 2012 resulted in flooding due to the ground being frozen (as a result of snow). Freeze-thaw cycles have in the past increased, hindering transportation to and from the mine. These have also raised many health concerns for the mine. Finally, the increased number of hot days has proven to be a challenge for employees as surface and underground temperatures increase. All the above mentioned impacts that were investigated were also seen to negatively affect the waste management area where the waste rock, sludge and retention dams are positioned.

Having identified the risks, a workshop was held with employees of Glencore to discuss how the identified risks affect business processes. A number of business processes were mentioned, namely:

- Tailings design affected by temperature and rainfall
- Transportation (including supply chain) affected by ice freezing
- Mine water balance affected by short and long term hydrology
- Infrastructure affected by extreme weather
- Closure affected by changing weather patterns
- Production affected by curtailment
- Labour force underground affected by increased heat days
- Compliance efforts affected by regulations due to unaccounted for cumulative impacts
- Energy security

A major challenge that was raised was the availability of data. For this study a number of sources were used to generate credible data that was useful for the mining company on a local scale. The data sources are listed were:

- Funding received from Natural Resources Canada’s Enhancing Competitiveness in a Changing Climate Program,
- Case preparation by Fraser Basin Council (FBC), partnership with Mining Innovation, Rehabilitation and Applied Research Corporation (MIRARCO) and the Ontario Centre for Climate Impacts and Adaptation (OCCIAR), and
- Golder Associates tool (Global Climate Change Model, Climate Generator)

Following the workshop that was held with employees, the case study highlights lessons and key learning’s from the entire study, which are used to inform adaptation methods. The key lessons learnt are:

- Knowledge sharing centres make a good contribution to climate change risk assessments,
- Consideration of both short term (weather) and long term (climate) changes is important as these affect different aspects of the mine lifecycle,
- Identification critical infrastructure at risk is vital as well as the protection of your labour force,
- Once physical climate change risks have been identified, care should be taken in the reclassification of water levels and tolerance in tailings,
- Input from employees through a workshop is important as different ideas are generated from individuals who have to personally deal with events. This also ensures that management methods being implemented are more readily accepted by employees as they feel they are part of the process,
- Identification of site-specific challenges is essential to design focused adaptation strategies,
- Internal agents of change can positively influence management methods and also ensure that all adaptation protocols are adhered to,
- Long term and short term adaptation strategies should be incorporated in management planning to further influence business strategy,
- A systematic way of addressing risks in terms of highest one (building resilience) should be employed, and
- Following the risk assessment and workshops, development of models for atmospheric contamination as well as water management is important for the company, in order to be in-house capacity to monitor changes.

Glencore continuously made reference to incidences in the past where unfavourable weather conditions had affected them negatively. Clearly visible is a good level of retrospect as well as forward thinking. The overall project was a success as a result of the following aspects:

- The workshops were not limited to the environmental department; they incorporated individuals in various rankings from different departments,
- They used “risk vocabulary” to account for climate change in existing risk strategies (e.g. loss of productivity, potential liability, supply chain threat etc.),
The drive for climate change consideration came mainly from a few selected individuals within the company where after the manager and a core group was established, Clear regulatory framework considering climate change risks and further engineering solutions accounting for this is important, and Incorporate climate change effects in existing organizational structures and thus it is easier to mainstream adaptation planning. Additionally they can contextualise which impacts affect which phases of the mine lifecycle.


The Nystar case study highlights how a mining company can respond to weather-related challenges such as severe storm events. The purpose of the case study was to highlight how past storm events have guided a mining company towards a risk assessment and response strategy. The intense storms experienced by Nystar resulted in the damage of mine site footings as well as the dilution of flood waters with mine effluents. Thus, the company had to develop strategies to address this business risk and by doing so, provide adaptation to future climate change events.

The case study identifies and assesses a physical climate change impact that is considered to be the most significant of all weather related risks. The physical climate change risk is associated with severe weather events, more especially severe storm events. The study documents extreme storm events that have affected the mine over 33 years (between 1979 and 2012). These intense rains come during winter seasons resulting in high surface runoff episodes due to the ice on the ground.

In 2006 Nystar mine received a storm event that is characterised as a 1 in 200 year storm. The heavy storm resulted in tailings pond overflowing, bridges being damaged, effluent backup and destruction of roads. During the flooding event, the employees and managers responded timeously in the following manner:

- Senior management lead with calmness and decisiveness,
- Sufficient emergency response equipment and personnel was available, and
- There was a quick and effective response from suppliers and contractors.
Even though Nyster was able to effectively manage the impacts of the 2006 flood event, the event highlighted numerous areas where management methods could be taken to restrict the impacts from becoming severe. Thus, the Nyster mine conducted a risk assessment; developed strategies to better equip employees as well as infrastructure and designed effective response methods. The following were the outcomes of the risk assessment:

- Scenario planning and development,
- Risk identification to assist in resilience development,
- Education and training of employees,
- Enhancement of monitoring tools and equipment,
- Site specific risk analysis and response,
- Link adaptation measures to other opportunities to enhance investment probability, and
- Perform continuous vigilance tests while creating dynamic management systems (do not rely on outdated frameworks that use a “know it all” strategy).

This case study shows how Nyster was able learn how to strategically plan for climate change related incidences, as a result of past experiences. It is important to note that although the mine experienced intense floods in 2006 and was able to deal with the impacts, numerous challenges were highlighted. Firstly, although compliant with regulatory requirements, physical infrastructure was unable to effectively deal with the surplus of water seen during that period. Secondly, Nyster highlights that local weather centres were unable to predict the severity of the storm. Lastly, the intense storms seen, resulted in compounded impacts such as flooding which was a challenge to mine personnel.

**Case 3: Anglo American, Metallurgical Coal, Australia (2010) – Rain Immunisation Project. Adapted from Anglo American (2010).**

Anglo American has identified that its Australian operations are in a zone that experiences extensive floods and droughts and further acknowledge that climate change could potentially exacerbate the situation. Thus, the company has developed a rain immunization project which aims to reduce the environmental risks of increased rain days while also optimising business productions. The purpose of the case study was to highlight how past events can be used to develop strategies that assist with building adaptive capacity while reducing the number of days that are lost due to flood events.
Anglo American highlights two business risks that arose as a result of climate change related events. These were; i) production reduction due to pits and underground flooding, and ii) disruptions in the transportation system. In addition to these risks, Anglo American explained that water is likely to overflow and come into contact with disturbed land, which may result in water contamination.

The outcomes of the project were; i) the improvement of road conditions; ii) increased pumping and piping capacity; iii) tracking and accounting of wet weather days which assists in preparation; and iv) maintaining constant production levels.

Although not directly related to mine rehabilitation, this case study has highlighted how adaptive strategies can be employed for frequent occurring incidences - which are likely to intensify in the future - in order to further enhance the resilience of the mine. Additionally, the mine has taken a long term approach in the design process of rain water capturing in order to ensure that the total number of down time days is reduced.

Local case studies


The purpose of the case study is to highlight how a climate change risk can be seen as an opportunity through the reuse of water on tailings dams. DRD Gold has identified that there is high use of potable water for irrigating tailings to suppress dust, ensuring slope stability as well as for preventing erosion. Water is also reported to be used immensely during the operations of the mine. With this, DRD has initiated the use of treated water which will be treated from a sewage waste water treatment plant. This water is intended for the use of irrigation of vegetation on the tailings. The company is in the process of implementing two such treatment plants in their projects in South Africa.

There has been one business risk identified in this case study. This is the increasing competition for water resources in the area, which is likely to be exacerbated with climate change. This could further adversely affect the mine by creating tensions with communities in the surrounding areas. DRDGold’s initiative to reuse grey water brings forth an opportunity.
The outcomes of this case study were twofold. Firstly, it can be seen that DRD Gold has developed both a mitigation measure (reducing water use) as well as an adaptation measure (reusing of waste water) in response to adverse environmental effects. Secondly, this initiative was achieved in collaboration with a consulting firm further showing that different expertise are required to effectively address such challenges.

**Case 5: Harmony Gold, Gauteng, South Africa (2014) – New approach to rehabilitation (Adapted from: Ross, 2014)**

The purpose of the case study is to bring to light how important species selection is in maximizing rehabilitation on a contaminated site. Harmony Gold, having been subject to the strict environmental regulatory boundaries in South Africa, has developed rehabilitation programmes that take a long term sustainability strategy. An opportunity was identified in rehabilitation planning where the company recognised that it contributes significantly to GHG emissions and thus restoration land can be used to counter this effect by creating effective carbon sinks. Therefore, rehabilitation is being used as a mitigation strategy. Additionally, the company is looking at the potential of biogas to support their metallurgical plants. All these strategies are beyond compliance.

The business risks that are faced by mining companies operating in South Africa continue to grow in light of the evolving regulatory environment. The government has adopted the ‘polluter pays’ principle which essentially hold mining companies liable for any contamination that may occur as a result of their mining activities. Therefore all mining companies are required to rehabilitate the land that has been disturbed.

The outcomes of the case study are in four main areas:

- Firstly, innovative rehabilitation strategies can be employed in contaminated mining sites. In Harmony Gold’s case, future plans include rehabilitating contaminated land with vegetation species that are effective carbon sequesters such as sweet sorghum, sugar beet and giant king grass. Additionally, the company is planning to plant energy crops on their waste lands in order to generate approximately 71 000 GJ of biofuel energy.
Secondly, mitigation measures pose an opportunity to any business.

Thirdly, Harmony Gold has shown that through the innovative rehabilitation efforts, there could be economic (long term sustainable vegetation is established), social (creation of jobs during rehabilitation and site monitoring) as well as ecological (carbon sink and rehabilitation capabilities) benefits.

Finally, this project was achieved through the collaboration of a network of individuals with differing expertise.


The purpose of this case study was to highlight successful rehabilitation programmes that have restored ecological functioning. Richards Bay Minerals, part of the Rio Tinto Group, has established a dune forest restoration program on the coast of KwaZulu – Natal. The aim of the programme was to establish and maintain sustainable development principles in the area that they are currently mining in. The rehabilitation programme is not only one of ecological significance, but also one that is beneficial to surrounding communities. Originally, the dune forests were as a result of both the changes in sea level and also climate around the Mozambican coast which lies in the Southern eastern regions of Africa.

Similar to the case study above, Richards Bay Minerals, failing to effectively rehabilitate the land that had been disturbed by mining activities, could face legal consequences. The ecological restoration programme undertaken by Richards Bay Minerals, displays how ecological processes can establish effective rehabilitation.

As part of the rehabilitation programme, Richards Bay Minerals collaborated with three institutions. These were the University of Pretoria, the National Research Foundation (NRF) as well as the Technology and Human Resources for Industry Programme (THRIP).
The case study had four good outcomes. Firstly, successful and sustainable ecological restoration has been achieved at the dune forests in the eastern coast of South Africa. Secondly, the mine ensures that there is continued monitoring and evaluation in the short and long term. Thirdly, forest restoration has been integrated well with sustainable land use by communities. Lastly, the restored land has enhanced conservation results as well as reduced biodiversity loss.

The restoration programme conducted by RBM is also contributing to the mitigation of climate change impacts through the sequestration of GHGs. Additionally, the stabilisation and restoration of the area also creates a substantial barrier to protect the near communities from potential sea level rise as well as from extreme storms, as has been predicted by climate change models. It is also good to note that this programme was initiated in 1978, soon after mining started in 1977 in the region. The programme was championed by a single individual in the group who was thoroughly passionate about ecology.

8.3 Summary
From the abovementioned case studies, five key themes can be generated. Firstly, it has been shown that many of the companies mentioned above have developed strategies in response to the growing pressures of physical climate change impacts experienced in the past. Companies have identified that the costs attributed to extreme events are large and could be mitigated against by developing certain strategies. However, it is important to note that a reactive strategy may not be the most beneficial, especially when possible costs incurred could be detrimental to the company. It may be of use to develop strategies in a proactive manner. Secondly, it has proven to be useful to involve employees in the processes that the company undertakes. By incorporating employees, it is more likely that the strategy to be developed and implemented has good support. It is also important to encourage the participation of employees in the decision making process as it makes them feel part of the project. Thirdly, a couple of the companies have shown that long term thinking is essential when working with environmental challenges. Although initial investment costs may be high and the payback period long, it is likely that long term planning may be beneficial to the company. Fourthly, collaboration has also appeared as a key feature of these successful case studies. The above case
studies point out numerous collaborations, these ranging from sourcing specialised expertise to obtaining funding for the project. Environmental challenges, more especially those related to climate change, require an interdisciplinary network to effectively address the problem. The use of interdisciplinary individuals during the risk identification process is very important as such people are able to offer their expert advice and thus the outcomes are bound to be precise and of high quality. And lastly, in some of these case studies, opportunity was the drive behind the innovation. In all the above mentioned case studies, there were substantive research efforts placed in gathering the most accurate data sets to work with. Similar techniques can be employed in complex challenges, a company can sought out an opportunity where after that opportunity can be addressed with an innovative and novel idea using good quality data.

Finally, some of the investigated companies had the following statements to say:

**Glencore:** “The impetus for consideration of climate change impacts and adaptation was driven in large part by select internal staff.”

“...a clearer regulatory framework within which to address climate risks and further guidance through enhanced engineering codes and standards were identified as means to further enhance adaptation action...”

**Harmony Gold:** “Companies that demonstrate responsibility and leadership in respect of mining land are those who are committed to their own sustainability.”
Chapter 9

9 Discussion

9.1 Key Findings

Lack of consideration of climate change impacts during mine rehabilitation: Sustainability Reports

The two major findings of this study came through the third research question. This question investigated whether South African based mining companies have considered the impacts of climate change during rehabilitation. Studies show that climate change is bound to affect soil erosion, TSF stability as well as contamination migration (Commonwealth of Australia 2006; ITRC 2009; Larsen and Kørnøv 2009; ICMM 2013) and thus the importance of climate change impacts during rehabilitation. The first set of collected data from Sustainability Reports, shows that only two (out of 17) mining companies have reported that they have considered the impacts of climate change (Exxaro and Harmony Gold). For Exxaro, climate change considerations surfaced from a study that identified droughts, floods and heat as potential negative impacts on rehabilitation. Among all the aforementioned impacts, droughts were identified to be of highest concern, and may consequently increase the general costs of land management. For Harmony Gold, climate change considerations arose as one of the risks for rehabilitation where high temperatures, droughts and floods were identified as potential disruptions to rehabilitation. The second set of collected data show that climate change - although thought to be important by mining companies, consulting firms and academia - is not considered during rehabilitation. The following paragraphs will therefore attempt provide reasoning behind these findings.

Firstly, it is clear from the reported information in Sustainability Reports that every mining company investigated has already started considering climate change mitigation options, mainly driven by regulatory developments. In South Africa, the carbon tax policy that is being driven by the National Treasury, is likely to be implemented in 2016, its implementation having been postponed from January 2015 (Merven et al., 2014). The carbon tax is being used as an economic instrument to reduce carbon emissions by firstly, reducing the demand of energy through higher tariffs; and
secondly, promoting fuel switching to less carbon intensive based energy production (Winkler and Marqurd, 2011). As part of the carbon tax, a fee of R120 per tonne of CO\textsubscript{2} equivalents will be charged; however, there will also be a threshold and exemptions for sectors that are exposed to the trade (National Treasury, 2013; Merven \textit{et al.}, 2014). The mining sector is the second highest consumer of electricity at 15% after the industry/manufacturing sector which is at 38% (DEA, 2013b). In addition to this, 88% of electricity being generated in South Africa is through coal-fired means, where coal consumption accounts for the highest primary energy supply and consequently the highest GHG emissions (DEA, 2013b). It is with such concerns that the mining industry has developed mitigation strategies which encompass energy and process efficiency in order to reduce the overall emissions as well as save costs. By doing so, companies are also reducing their vulnerability to the carbon tax to be implemented in 2016. Other regulatory developments within the climate change mitigation field are the carbon budgets which were mentioned in the NCCRP in 2011 as part of a method to achieve Desired Emissions Reduction Outcomes (DEROs) to be implemented by the DEA (Cloete \textit{et al.} 2013; DEA, 2015). Additionally and more recently, the Draft National Greenhouse Gas Emissions Reporting Regulations released in June 2015 by DEA (Cloete \textit{et al.} 2013; DEA, 2015). With all these regulatory instruments surfacing, companies are being steered to react appropriately in order for them to not incur financial costs due to inefficient processes (which consume too much energy) or high GHG emission. The second research question being investigated is what do international and local guidelines on post closure practices state about climate change considerations? The investigated international guidelines show that international documents take a more detailed approach in explicitly stating the scientific relationship between rehabilitation and climate change in general. Legal local documents focus less on the scientific associations but rather on the duties that should be taken by mining companies and the repercussions thereof should noncompliance occur. From the investigated documents one may be inclined to believe that the onus is on each mining company to identify the factors that may result in unsuccessful rehabilitation and further ensure that these are addressed. In summation, it appears as though all mining companies have investigated mitigation options due to forthcoming regulatory requirements while adaptation options
have been rarely considered as a result of what is currently perceived to be minimal financial
implications as shown in Nelson and Schuchard (2009), Pearce et al. (2011) ICMM (2013).

Lack of consideration of climate change impacts during mine rehabilitation: Interviews
Secondly, the interview process also highlights the perception that adaptation measures are
difficult to implement since these are not easy to quantify. This has been shown to be true by McEvoy
et al. (2010). On enquiring about the theme of rehabilitation during the interviews with mining
companies, similarly to the findings of Prno et al. (2010), all participants stated that rehabilitation is in
accordance with current and/or historic conditions as information is obtained from baseline
conditions, specialist studies as well as rehabilitation standards. On the theme of climate change
awareness, the interviewees stated the general South African projections that are expected as opposed
to the more specific site level changes. Only one of the participants explained that their current site
operations are significantly affected by floods and thus the increased intensity of floods due to climate
change may be an additional threat. This is the type of systematic thinking required to address the
matter at hand. Importantly, most of the companies already have in place climate risk assessments
which are predominantly focused on operations and the responses are mitigation strategies which
result in direct benefits. One participant explained “…there is still a great need to incorporate and
implement the strategy in closure planning.” Additionally, there is awareness that current standards of
1 in 100 year floods may need to be revisited should flood frequency and intensity increase.

Generally, the interviewees have awareness, but may be lacking slightly on strategies to
address the issue, especially in adaptation. Comments that support this were; “We understand climate
change, it’s just that we don’t know what to do about it.” “The company finds it difficult to look at
long term time frames like 50 years +, even though it does recognise the long term implications.”
“The company is not sure what to do in response besides conducting trials which are extremely time
consuming especially with the uncertainty in climate change.” “There is also a lack of strategic
development at the government and NGO level thus there needs to be work done at those levels first.”
“The company is aware of what is generally going on but company has not really changed much.” “It
is a great weakness that the company has not considered climate change at rehabilitation.”
In many cases that involve climate change adaptation measures, the extent, feasibility, efficiency as well as the cost effectiveness of many initiatives are unknown, and thus this presents a challenge to companies where projects have to be quantified financially (McEvoy et al. 2010). Similar sentiments are shared by mining companies during the interviews; where due to the uncertainties in the physical impacts of climate change, companies state that developing adaptation measures is a cumbersome task to undertake. Companies, in most cases, require a good business case to implement initiatives, and with physical adaptation measures it is difficult to quantify the payback period and return on investments. As has been shown in Milner and Dietz (2015), the quantification of adaptation measures produced by the World Bank in 2010 has received much criticism due to the assumptions made and elements that have been eliminated to reduce complexity. Milner and Dietz (2015) argue that adaptation measures to climate change require a dynamic approach by firstly determining the qualitative parameters (which are uncertain) and understanding how these qualitative parameters affect the quantitative results. Additionally, in developing adaptation measures, it is important to describe explicitly what effective adaptation will be and the underlying measures that need be taken (Milner and Dietz, 2015). It may also be of use to track adaptation using the framework by Ford and Ford (2014), which essentially highlights the four major Cs (consistency, comparability, comprehensive and coherence) that need to addressed which assist in monitoring measures over the long term period as well as across different regions (Appendix 3).

Relaying this adaptation reasoning to the context of this study, uncertainty exists in the predictions of physical climate change impacts and therefore this poses the first hurdle. However, findings as has been shown in Chapter 4 from literature produced by Midgley et al. (2001), Midgely et al. (2007), DEA (2013), DEA (2013a), and IPCC (2013), show that physical climate change impacts are highly likely in South Africa starting from the near future and potentially becoming more frequent and intense in the far future. And therefore, these findings can be the starting point of discussions for adaptation measures going forward. Furthermore, as seen in the FBC and Mirarco (2014), FBC and Mirarco (2014a) and Anglo American (2010) case studies, previous exposure and vulnerability initiated climate risk assessments and the need to develop some level of adaptive
capacity. These aforementioned companies have, to a certain degree, been able to quantify how changes in the qualitative field (e.g. increasing intensity and frequency of rainfall etc.) may affect the quantitative results (e.g. costs to the company due to down time, costs incurred to fix damages etc.), and thus their ability to develop adaptation measures. Therefore, these case studies show that identifying intense weather conditions that affect the company (whether at exploration, operation or closure) negatively, is a good starting point and reference measure to quantify how the financial implications as both investments and costs.

Further analysing qualitative components informing quantitative elements, this can be applied in rehabilitation phase where, for example, the financial implications of not complying to the legal water quality standards can be used as a metric to decide on whether the tailings dam design and rehabilitation vegetation species should be changed to ensure that water contamination in the future does not occur. In the case of tailings designs or open cast designs many mining companies have been able to identify the volume of rain that has resulted in overflowing of open facilities and therefore these events can be of assistance in placing more quantitative value to adaptation planning. With regards to rehabilitation, for instances where water quality investigations show varying levels of quality between high/ low rainfall and high/low temperature seasons, these could also be used as starting proxies which simulate the potential future occurrences that are likely to be exacerbated. Thus, in summation, adaptation decisions can be gradually developed with the current information at hand to further quantify the financial implications for the future.

**Climate change and water issues**

Thirdly, in terms of water related issues, recently the Carbon Disclosure Project (CDP) has introduced the water disclosure, which although still voluntary, requires companies to report on their water consumption, risks as well as initiatives. Again, most of the Sustainability Reports mention elements of ensuring that water is not contaminated and also that water is available to surrounding communities since it is a shared resource. Water stewardship is one of the vital elements in the mining sector that ensures that mining companies retain their license to operate (Kemp et al., 2010). The interviews as well as the Sustainability Reports highlight how water availability is crucial in order to
maintain operational processes and thus the direct impacts of unavailability transpire faster and present an immediate concern for mining companies. This is in comparison with the rehabilitation phase where water concerns, although said to be important, are not prioritised as much. An example where water supply has been considered during rehabilitation is the DRD Gold case study in Chapter 8. As seen, grey water is used to irrigate tailings facilities. On further investigation through the company’s other public communications such as the 2014 Integrated Report and website, water and dust are highlighted as the key environmental issues that DRD Gold faces. To contain the dust, DRD Gold irrigates the tailings with water as well as establishes vegetation, which also needs to be irrigated (DRD Gold, 2014). DRD Gold further mentions that water is material to the business and that the company currently runs a closed loop system, recycles water contained in the slurry as well as harvests rain water; all in efforts to conserve water for both their operational and rehabilitation processes (DRD Gold, 2014). As has been discussed in the literature review, the gold mining sector has in the past and currently faces immense financial and legal burdens due to water contamination that has been seen in the Witwatersrand basin (Bell et al., 2001; Bakatula, 2009). It is therefore expected of a gold mining company to have such high regards for water management, as seen with the DRD Gold case study. Thus, although this case study shows that water is an important aspect and hence the initiative that has been taken to conserve the resource; the primary reason may not be that related to climate change but that relating to public perception and past experiences, as will be further discussed in the paragraphs below. However, in the long term the current initiative will provide some adaptive capacity for the mining company, when water shortages arise in the area. In summation, water availability issues are seen to be more detrimental to the operational phase and where companies have considered water issues in rehabilitation the underlying factors appear to be past experiences making water a material issue as well as concerns with public perceptions.

Climate change and public disclosure requirements

Fourthly, although JSE SRI listed companies are not required to report according to GRI Guidelines, investigation in Chapter 6 show that, of the 50 Sustainability Report documents reviewed, 48 reported in accordance with GRI Guidelines, where 48% declared a GRI G3 A+ application level. Furthermore, this suggests that almost half of the reports reviewed made use of the Sector
Supplements (Mining and Metals Sector Supplement) and also had their data externally assured (GRI 2010; GRI, 2011). Gathered results show that top level performing companies that report according to GRI G3 do not provide specific information that pertains to this study (i.e. climate change and rehabilitation). The two companies that report on climate change having an impact on rehabilitation, self-disclose an application level G3 B+ and basic GRI G3 guideline application (Exxaro and Harmony Gold, respectively). The high level of application of the GRI G3 Guidelines, greatly explains why all companies have reported on GHGs and mitigation measures as this is required for the Emissions, Effluents, and Waste aspect (Table 2-1) (GRI, 2010). Such disclosures are additionally required by the JSE SRI (JSE SRI, 2013). All companies reported on negative environmental impacts and the control measures in place as of the JSE SRI (2013) requirements. Research conducted by Dawkins and Fraas (2011) shows that although a general perception is that companies report in accordance with regulatory pressures, the greatest demand is actually driven by public visibility and media pressures. These authors argue that companies voluntarily disclose environmentally related issues when media directs the attention in that area, resulting in stakeholders placing more responsibility on the company to report in response. However, based on the findings of this research, we conversely argue that media does play a role but in only directing the attention towards an issue that has already been placed on the regulatory context agenda, and thus the underlying effect would still be the growing regulatory pressures that media capitalises on. Environmentally well performing companies find voluntary public disclosure exercises as suitable tools to acquire a competitive advantage, while poorly performing companies make use of this opportunity to discuss what measures have been placed following the negative experiences (Dawkins and Fraas, 2011). This further explains why most of the bigger international companies self-declared a GRI G3 A+ (e.g. Anglo American, Lonmin, Sasol, BHP Billiton) level as opposed to the local and smaller companies which either did not make a self-declaration or self-declared a lower level (e.g. Royal Bafokeng Platinum, Sibanye Gold). International companies are faced with greater public pressures due to their operations being across the globe, in comparison to the local companies who have one of two mines around the country.
In the context of the aims and objectives of this study, findings by Dawkins and Fraas (2011) can be used to understand why climate change and rehabilitation may not have been well disclosed considering the high GRI application levels that were self-declared. In addition to public voluntary disclosures being driven by visibility and media, these forces also greatly drive the content of what is disclosed at a particular time (Dawkins and Fraas, 2011). And as seen in the literature presented in Chapter 1 and 2, there is a growing pressure in the carbon environment within the country, which potentially explains why all mining companies have reported on emissions and mitigation options as opposed to the physical effects of climate change on rehabilitation. This is in addition to what has already been discussed in the former chapter on mitigation measures. The awareness that has been generated in the mitigation arena has assisted companies in understanding their emissions and identifying areas that can be easily worked on. This can similarly be applied in the adaptation field where by monitoring weather events, companies can develop appropriate responses with media also giving attention to these activities.

To review the previous paragraphs, this study has found that climate change has not been considered well during rehabilitation and there are subsequently four key elements highlighted by this study possibly explaining why climate change has not been greatly considered. Firstly, the regulatory environment in the country has placed an emphasis on the implementation of mitigation options and to a lesser extent on adaptation options especially towards the end of the mine-lifecycle. In addition, from the literature reviewed in Chapter 5 it can be seen that all mine closure legislation was promulgated before South Africa had presented a stance and direction for climate change. Secondly, literature shows that adaptation is difficult to quantify compared to mitigation; however, there are qualitative and quantitative ways to account for adaptation. Thirdly, the study highlights how water issues have in the past proven to be problematic and how past experiences can be used as good proxies for future trends and to further develop adaptation. Although increased variability is expected with climate change, indicators of past events when considered in light of likely climate change impacts could serve as good interim indicators. Finally, environmental reporting appears to be driven
by current topics in the media in addition to regulatory pressures, and this possibly explains the findings in the public disclosures.

9.2 Other arising factors

The first objective of the study aims to display which climate change impacts will affect the investigated mining companies. The maps display impacts such as heat, water as well as biome distribution due to, but not limited to, soil moisture. Even though the maps do show some regional implications of climate change, it has been shown by Mukheibir and Ziervogel (2006) as well as Dennis and Dennis (2012), that projections using downscaled GCMs contain uncertainty thus restraining assurance in the generated results especially in terms of the extent of the impacts. However, it has been reiterated by Mukheibir and Zeirvogel (2006) that the general patterns generated by such models can be understood with better confidence. Thus the maps displayed in Chapter 4 can be seen as an indication of the patterns of climate change with a slight uncertainty of the extremities of the impacts identified. Additionally, research on climate change and adaptation development has been encouraged to focus especially on short term (10–15 years) time frames for climatic predictions as these time frames show much more certainty; where after more details shall arise with time on long term predictions (Muckeibir and Zeirvogel, 2006). Research on regional climate models (RCMs), such as that done by Engelbrecht et al. (2009), has been gaining momentum in the continent further detailing finer details of what to expect in South Africa especially. Therefore, as has been suggested by Muckeibir and Zeirvogel (2006), when scientific findings narrow the uncertainty gap in due time, added specific measures can be taken. This is; however, not to eliminate action in adaptation measures at present, as general patterns have already been identified.

The second objective was to review both local and international guidelines on closure and rehabilitation. Note worthily, only two of the reviewed documents mentioned climate change considerations during the rehabilitation process. These were by the ITRC (international research) as well as the CoM (local guidelines). Both these documents revealed specific details on rehabilitation and thus climate aspects were inevitably mentioned. It is also important to note that other documents, such as those by the ICMM, did also slightly allude to climate considerations; however, this was not
as explicit as in the prior mentioned documents. Since legislation has not explicitly stated that climate change consideration should be accounted for during rehabilitation, this may be the reason why mining companies have not considered it in detail, as already discussed above. Further to support this reasoning is the recommendation made in Chapter 8’s Case Study 1, where legal frameworks are a recommended so as to continuously foster a rehabilitation planning environment conducive to climate change. Additionally, although legal and regulatory requirements have been recommended by Prno et al. (2010) to further establish a well-defined protocol to follow, it has been shown that such an approach may result in unintended consequences. The imposing of legal requirements may potentially result in delayed company outcomes, as perceived by investors since many investors require that a particular project gains regional endorsements prior to funding being granted (Prno et al. 2010). Thus even though the stringent application of legal frameworks may be thought to be assisting the situation, it may pose a threat to the company should the government administrative procedures be too time consuming.

Finally, some mining companies suggested that rehabilitation areas will be able to adapt to the changing climate based on the assumption that physical characteristics of the area to be rehabilitated will not have changed significantly as well as assuming that the programme will be a success from the initial phases. From this it becomes apparent that the serious implications are being shifted to future managers, which at that time will most probably be more expensive to deal with. As has been shown in Prno et al. (2010) as well as in Case Study 1 (Chapter 8), adaptation planning at present will result in costs savings as opposed to reacting to climate change risks in the future.

A view from the consultants and academics shows that climate change is seldom integrated into rehabilitation especially because: i) There is a lack of understanding of climate change and how to incorporate it, ii) There is no sharing of climate change related information, iii) Climate change requires long term thinking and most mining companies fail to do so especially for rehabilitation, iv) Environmental issues affecting the company are mostly concentrated within individuals in that specific department and there is little integration with other departments. Furthermore, these participants then encourage the use of multidisciplinary networks and individuals to assist in
knowledge sharing systems and planning programmes. A recommendation is that the government should collaborate with research institutions as well as mining companies and consultants to provide solutions that are all encompassing.

The last objective was to review case studies with hopes to identify the key lessons that could be used in the South African context. The research question was, how has climate change been considered in mining companies based internationally and locally? Overall, the case studies collectively show that companies need to be driven by that need to understand the risks of climate change, similar to the needs of understanding other business risks. A call was made to stop approaching climate change issues as solely being environmental ones but rather as general business issues to fully understand the complexities involved with such issues.

From Case Study 1, it is apparent that increased above ground temperatures do actually affect the below ground temperatures due to incoming ventilation. Conversely, one mining company had said that underground temperatures are not likely to be affected by increasing surface temperatures. This is evidence that mining companies have still not been able to comprehend the entire direct and indirect implications of climate change throughout the entire mine lifecycle.

In many of the interviews conducted, especially with the interviewees from mining companies, it was mentioned that although personal efforts had been made to influence change and mainstream environmental and climate change issues further in other business structures, it proves to be very difficult with minimal support. However, looking at Case Study 1, 2 and 6, it can be seen that an individual can be a good agent of change. These Case Studies have shown the good outcomes when participants on the ground as well as those in higher managerial positions are included. The projects discussed in Chapter 8 were initiated by single individuals who gained support from employees on the ground as well as higher ranked individuals to further broaden knowledge sharing. Characteristics shown by these leaders are synonymous to good sustainability leadership.

Case Study 1 and 6 affirms what has been recommended by consultants and academics during the interview process. It was recommended that climate change issues not be framed as such, but
rather weather related issues to remove some element of uncertainty and long term thinking that mining companies are unable to do. This recommendation supports views expressed by Muckeibir and Zeirvogel (2006) of developing adaptation strategies in response to climate variabilities in the short term where changes are more certain and known. As seen in Case Study 1, the questions posed during the workshop were “How does weather affect your work?” and thus “How would future climate extremes most likely affect your work?” Additionally, from the Chapter 7, a recommendation from academic institutions was that since most mining companies desired more engineered solutions, it would be best to rather address adaptation in terms of climate variability, only factoring in climate change later. By taking the climate variability approach, it is thought that there is more certainty of impacts and these are well understood and can thus be incorporated in planning. On the contrary, interviewed participants see uncertainty in climate change impacts, thus the scepticism in including impacts when planning. There is credible data when observing climate variability, hence this could be a possible approach for planning (Engelbrecht et al., 2009).

9.3 Way forward
Having identified and gathered data from mining companies, consultants, academics as well as showcasing the success stories, there now needs to be an element which attempts to address the presented challenges. Overall, the inclination to address more mitigation options than adaptation is not a new finding. Other studies by Haque and Deegan (2010) and Prno (2010) have shared the same sentiments, especially for the mining sector. Knowing this, there now needs to be an identification of which elements contribute to this occurrence. Firstly, it is important to explicitly state the dominant challenges that prohibit the consideration of climate change during rehabilitation and secondly to understand how these challenges can be addressed. Therefore presented below are the challenges as well as the strategies to address the challenges further assisting in adaptation development (Ford and King, 2013).

Data sources and management systems
Uncertainty, which transpired in all interviews, is mainly due to the current projections which seldom present the regional impacts which are more useful to the companies. Ziervogel et al. (2014) also shares similar sentiments where it is shared that the country significantly lacks country wide
modelling irrespective of the research that has been conducted in Earth Systems Science. From the Case Studies in Chapter 8, is has been seen that good data management systems immensely assist in developing appropriate response strategies whether in the form of adaptation or mitigation measures. Knowledge of the actual regional impacts further outlines the key vulnerabilities in the area (Prno et al. 2010). Such may be achieved through the use of local weather stations as well as research institutions (Prno et al. 2010). Studies such as those done by Engelbrecht et al. (2009) are a stepping stone to achieving full RCMs for the country. As suggested by many of the participants, these can be further hosted by institutions such as the ARC, the CSIR or SAEON. Basher (1999) has also recommended that immediate adaptation measures can be developed in response to climate variability since climate change is projected to be partially the exacerbation of climate variability. Credible data information is required at three levels during adaptation planning: i) during research, ii) during the advancement methods and iii) during monitoring and evaluation (Basher, 1999). Lastly, the data available should also be available in a format that can be easily interpreted by the non-scientific audience such as mine managers, investors and other stakeholders.

Legislation, regulations, guidelines, company policies and procedures

Through the investigations done for this study it has been suggested that implementation of governmental legislation and regulations will potentially raise awareness of the impacts and reciprocally encourage companies to take adaptation measures. Moreover, a certain regulatory environment assist in setting a direction for interested and affected parties, more especially mining companies. Additionally, Haque and Deegan (2010) have shown how company policies and procedures can further assist in risk identification and further development of best strategies to address the risks. General adaptation guidelines can also be presented to the company once the key vulnerabilities have been identified (Prno et al., 2010). Additionally, it has been emphasised by Ford and King (2013) that such governance documentation should be based on qualitatively and quantitatively good climate change data hence data sources and management systems play a vital role overall. Also of importance to note is that there is currently work being done in researching the efficient system to assess adaptation measures by the national government (de Franca Doria et al., 2009; Ziervogel et al., 2014).
Cross disciplinary collaborations

Thus far it has become apparent that many hurdles are encountered when individuals and departments work on their own projects without fully communicating with each other. As additional observations made with interviews from the mining companies, interviewees generally did encourage the consideration of climate change as well as other environmental issues within all business sectors. However, the structural dynamics of the company tend to make effective integration difficult. As also shared by consulting interviewees, in many cases climate change awareness is concentrated within the environmental and sustainability departments when it is in actual fact an issue affecting the entire business. Ford and King (2013) thoroughly encourage the transdisciplinary nature required for effective adaptation planning, as it is important to know that all stakeholders are affected and depend on each other. It was also seen from the Case Studies in Chapter 8 that good outcomes were the fruits of collaboration with multi-disciplined stakeholders, from not only within the different departments of the mining company, but also other external parties such as academic institutions, research bodies, funding programmes, government officials as well as other interested and affected parties. Collaboration is also seen to be a vital way forward in adaptation planning as shown in Ziervogel et al. (2014).

Research and development

A gap that was also identified was the availability of research findings from academic institutions. It was expressed by all interviewed parties that in most cases academic institutions such as Universities are able to study the longer term impacts of changes more specifically in the rehabilitation field. Additionally, consulting firms felt that sufficient research had been done; however, this had not been presented in the appropriate channels to further assist in decision making. Thus, such institutions play a vital role in bridging the knowledge gap and further advising on what should be implemented in the mine lands to enhance adaptation planning (Ziervogel, 2014). It is also of importance to note that some mining companies are already working with academic institutions to conduct site specific studies therefore this shows that there is keenness to collaborate. Institutions that are already part of investigating rehabilitation science are the Stellenbosch University, the University
of the Cape Town, the University of KwaZulu Natal, the University of the North West, the University of Pretoria as well as the University of the Witwatersrand.

**Funding**

Intensive research and development cannot be pursued without substantial funding to carry out the research. As has been seen in the Case Studies presented, funding initiatives assisted greatly in achieving the desired results not only during research but also in the implementation and monitoring of programmes. It has also been stated by Ford and King (2013) that continuous multiyear funding should further assist adaptation programmes to ensure that the initial objectives of the programs have been fulfilled. This funding contributes to research and development, implementation, monitoring and evaluation, contracting specialists as well as employing additional staff for the adaptation programme (Ford and King 2013).

**Managers and sustainability thinking**

As was observed from the mine interviewees, there is a capability and willingness of stewarding good sustainability leadership but the hurdles appear to be too great for the individuals. Strong leadership that is able to foster an environment of transdisciplinary interactions is vital in achieving success for adaptation planning (Ford and King, 2013). Innovative ideas will also bear fruit from such transdisciplinary networks (Ziervogel et al., 2014). It is also important that such individuals are able to consider the long term implications and additionally act on these, irrespective of whether that individual will be in that role in future or not (Ziervogel et al., 2014). There is an increasing need for individuals to develop a new way of thinking deeply embedded in systems thinking to further understand the complexities of current issues (Reams, 2005). Leaders that effectively champion such endeavours will have developed past the intellectual capacity furthering into the psychological sphere where higher meaning and social interactions are used as mechanisms to facilitate the sustainability agenda (Reams, 2005). This has been said to be of good practice in business situations which have identified innovations in complexities (Reams, 2005).

### 9.4 Conclusion

Degraded and contaminated land as a result of mining activities is already characterised by its poor ability to foster good ecosystem functionality and thus the climate change impacts pose an
additional threat. Additionally, in some instances vegetation being used for rehabilitation is not indigenous to the area and thus is susceptible to stresses of a new environment, therefore climate change poses an additional stress for the species. Climate change adaptation appears to be overshadowed by the better legislative requirements already in place for mitigation, curbing GHG emissions and financial instruments such as the Carbon tax; hence companies addressing what are thought to be more urgent issues of mitigation. It has been shown that ecosystem resilience is enhanced with the implementation of good adaption programmes which further benefit the surrounding communities (Kotze and Ellery, 2009; Ziervogel et al., 2014). Although some mining companies (a very small proportion) have developed the necessary measures regarding rehabilitation; a vast majority are still at the uncertainty level mainly because projections simulate the years 2050 or 2100 which do not appear to be in the near future and also the lack of RCMs. However, it is important to note that strategies such as the NCCR P (2011) show varying time frames in which to respond to climate change (short, medium and long terms; in 5, 20 and 30+ years, respectively). This approach assists in breaking down goals to achievable lengths further motivating individuals to pursue longer term goals.

As has been stated by Haque and Deegan (2010), climate change generally affects the company’s productivity and worth in two major aspects; firstly through the introduction of carbon costing instruments and secondly through the physical impacts to the infrastructure. Strategies to address the former manifest as mitigation measures; while strategies to address the latter manifest as adaptation measures. Generally, a trend that was seen was that in some instances, there are adaptation measures in place but these are not necessarily to deal with the direct physical impacts of climate change but are rather in response to the developing legal environment. For example with energy efficiency, it is regarded as an adaptation measure to a legal and economical environment where carbon costs will be high and also the costs of GHG emissions will be high and thus mitigation measures in place also form an adaptation, but vastly motivated by the legal and economic environments. On the other hand, in an instance where a company identifies the increased frequencies of floods and how these are affecting the tailings dam capacity and in response develop systems to
monitor the capacity of the dam (seen in Case Study) they have adapted to the physical impacts of climate change as well as meeting regulatory requirements.

Some findings show that flood events are becoming more frequent and therefore adaptation measures need to be taken now since the cumulative impacts of these events will result in large financial implications. A recommendation from the interviewees as well as other publications prefer that climate variability be addressed in the short term as research is being done. Where after the surfacing of research outcomes shall further necessitate the development of long term adaptation policies and procedures.

**Recommendations**

As explained earlier, a qualitative research approach is undertaken to understand the base drivers within complex systems. Furthermore, such an inquiry creates the foundations on which quantitative research can launch addressing the qualitative findings. It is important to note that there could be a continuation of qualitative work still to be done in this field as this study covered the mere essentials without actually delving into the deeper complexities. Therefore future studies to further build onto this research can address the following areas:

- Investigate what the governments’ perspective is towards climate change and rehabilitation within the mining sector, especially in terms of adaptation.

- Development of a tool interface consisting of climate variabilities as well as climate change data, factoring in anthropogenic influences.

- Investigate whether a body consisting of mining sector officials, consultants, academics as well as government officials can be formulated, and if so which would be the best institution to host it. This strategy is likely to enhance knowledge sharing and collaboration.
Appendix 1a: Participant information sheet

Participation Information Sheet

Research Title: Assessing whether rehabilitation programmes from South African mining companies have considered the impacts of climate change.

Good day,

My name is Zniko Ndlovu and I am a Master of Science student at the University of the Witwatersrand. As of the degree requirements, I am conducting research on mine rehabilitation and climate change (i.e. the impact that climate change will potentially have on rehabilitation). This research will assess whether climate change has been considered in rehabilitation programmes in mining companies that are operating in South Africa. To determine whether climate change is having an influence on mine rehabilitation planning I am asking individuals, such as yourself, to participate in an informative interview process.

Your input in this interview process will enlighten on current practices in rehabilitation and provide information on the awareness that the effects of climate change could potentially have on the business risk. The findings of this study will also aid in providing the mining sector with possible technical solutions that may not have transpired as a result of the lack of and the scepticism surrounding climate change. In turn, this research will also form the basis into the direction in which mine rehabilitation research should proceed, which is towards considering the effects of climate change more.

I therefore wish to invite you to participate in this study. Your participation is entirely voluntary and refusal to participate will not be held against you in any way. If you agree to participate, I shall conduct an interview with you which entails semi-structured open ended questions that you may answer and these answers will be audio-taped. The interview will take approximately 30 minutes. You may withdraw from the study at any time and you may also refuse to answer any questions that you feel uncomfortable with answering.

Please be assured that the company name and your personal details will be kept confidential and no identifying information will be included in the final research report, and thus any reference made to the company will be made under a pseudonym.

Please feel free to pose any questions regarding this research. I shall answer them to the best of my ability. I may be contacted via email (Zniko.Ndlovu@students.wits.ac.za), or via my supervisor, Ingrid Watson at Ingrid.Watson@wits.ac.za. The findings of this study will be reported in a research report which may be available on the University’s online repository. Should you wish to receive a summary of the results of this research, an abstract will be made available on request. There will be no rewards for participating in this research.

Thank you for taking the time to consider participating in the research.

Yours sincerely,

Zniko Ndlovu
Appendix 1b: Request for permission

REQUEST FOR PERMISSION TO CONDUCT RESEARCH

Research Title: Assessing whether rehabilitation programmes from South African mining companies have considered the impacts of climate change.

Good day,

My name is Zniko Ndlovu, a Master of Science student at the University of the Witwatersrand (WITS). The research I wish to conduct for my Master’s research report involves exploring whether South African mine rehabilitation programmes have considered the impacts of climate change. This research will be conducted under the supervision of Ingrid Watson (Centre for Sustainability in Mining and Industry, School of Mining Engineering, WITS) and under the advisory of Isabel Weiershye (Ecological Engineering and Phytotechnology Programme, School of Animal Plant and Environmental Sciences, WITS).

I am hereby seeking permission to approach employees as participants of the research. The employees may be involved in any of the following departments within the company: closure planning, sustainable development, environmental management and / or technical solutions. Please be assured that the company name and personal details of employees will be kept confidential and no identifying information will be included in the final research report, and thus any reference made to the company will be made under a pseudonym.

Upon the granting of permission, the participant(s) will be provided with a detailed information sheet which further elaborates on the research, a consent form to additionally inform the privacy and terms of participation, and also the approval from the WITS Research Ethics Committee for Animal and Human (Non-Medical) research.

If you are willing to grant permission, may you kindly sign the section below that acknowledges that you have read this request letter and give permission for the research to be conducted in the premises of the company or alternatively telephonically where the former is not possible. Should you require any further information, please do not hesitate to contact me on 073 562 6615 or Zniko.Ndlovu@students.wits.ac.za.

Thank you for your time and consideration of this matter.

Yours sincerely,
Zniko Ndlovu

I [Name: ____________________________] as
[Role/Title: ____________________________] of

[Company name: ______________________] having been informed about the research titled Assessing whether rehabilitation programmes from South African mining companies have considered the impacts of climate change, give permission for the study to be conducted. I reserve the right to withdraw this permission at anytime.

Signature: ___________________________ Date: ___________________________
Appendix 1c: Consent form

Consent Form for Participation in the Research

Research Title: Assessing whether rehabilitation programmes from South African mining companies have considered the impacts of climate change.

I have been informed of the purpose for this research and hereby consent to be a participant in the questionnaire on part of the research report. The purpose and procedures of the study have been explained to me. I understand that my participation is voluntary and that I may refuse to answer any particular items or withdraw from the study at any time without any negative consequences. I understand that my responses will be kept confidential.

Additionally, I agree / disagree (please circle the appropriate) to being audio recorded, as brought to my attention in the Participant Information Sheet.

Name of participant: __________________________
Date: __________________________
Signature: __________________________
Appendix 1d: Ethics clearance certificate

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/09 Ndlouv

CLEARANCE CERTIFICATE

PROJECT TITLE
Assessing whether rehabilitation programmes from South African mining companies have considered the impacts of climate change

INVESTIGATOR(S)
Ms Z Ndlouv

SCHOOL/DEPARTMENT
Animal, Plant and Environmental Sciences

DATE CONSIDERED
20 June 2014

DECISION OF THE COMMITTEE
Approved Unconditionally

EXPIRY DATE
21/08/2016

DATE 22/08/2014

CHAIRPERSON (Professor T Milari)

cc: Supervisor: Prof  I Watson

DECLARATION OF INVESTIGATOR(S)
To be completed in duplicate and ONE COPY returned to the Secretary at Room 10000, 10th Floor, Senate House, University.

I We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I We guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I We undertake to resubmit the protocol to the Committee. I agree to completion of a yearly progress report.

Signature

Date 28/08/2014
Appendix 1e: Mining company questionnaire

Questions that probe key areas of discussion: Mining companies

Theme 1: Introducing the participant’s profession

1. What is your position?
   a. What does your position entail
   b. How long have you been working for the company

2. Describe the mandate and purpose of this department within the company and at which stage of the mine lifecycle is this department needed the most?

Theme 2: Unpacking the information for rehabilitation programmes

1. Is the company aiming to restore or rehabilitate the area being impacted by the mining activities?
   a. What restoration / rehabilitation programmes have been designed that will be further implemented post mine closure?
   b. Is the programme to be implemented a water intensive plan?

2. What source of information is required for restoration / rehabilitation and how is this information obtained?
   a. Probing: Are the climatic conditions important when such information is obtained?
   b. Is rehabilitation then planned in line with these baseline conditions in mind?

3. How often are the restoration / rehabilitation programmes reviewed in the financial provision statements of the company?

Theme 3: Awareness of climate change effects within the company and at rehabilitation

1. Is the company aware of climate change and the recent predictions?
   a. Can you elaborate on what is known about climate change

2. Is the company aware of any of the business risks that may arise as a result of climate change (these may pertain to the entire mine lifecycle)?
a. Can you elaborate on some of these business risks?

b. Will climate change affect the company negatively or positively?

3. Are there any mitigation and / or adaptation plans that have been developed in light of climate change (i.e. energy consumption, water use, carbon emissions etc.)?
   a. What potential gains could the company incur as a result of these plans?

4. According to the information that has been obtained on rehabilitation and climate change, does the company feel that current rehabilitation programmes that have been planned will be significantly affected by a changing climate?
   a. What types of changes are you anticipating OR why are there no changes anticipated?

5. Have you considered how climate change may affect the types of covers placed on top of tailings, the species used for restoration / rehabilitation and the capacity that slimes dams have?

6. Are climate change impacts included in environmental impact assessments at any stage of the mine lifecycle?

Theme 4: Reviewing past measures taken and some external agents that assisted

1. Are there any case studies on climate change and / or rehabilitation that I may review which may further elaborate how the company’s mitigation and adaptation strategies are?

2. Which consulting agents is the company most frequently in contact with when it comes to rehabilitation planning?
Appendix 1f: Consulting company questionnaire

Questions that probe key areas of discussion: Consulting firms

Theme 1: Introducing the participant’s profession

1. What is your position?
   a. What does your position entail?
   b. How long have you been working for the company?

2. What is the role of this department in the companies consulting services to the mining sector?

Theme 2: Views on mining clients/sector

1. What are the thoughts and views that most of your mining clients have towards climate change?
   a. Is there still too much uncertainty in the scientific concept for the companies to start taking precautionary measures in planning (e.g. environmental, financial, social etc.)?

2. What is the level of awareness towards climate change portrayed by the mining companies that you have worked with?
   a. Is there more or less awareness in the rehabilitation phase of the mine lifecycle?
   b. Can you rate the extent to which climate change is of concern at rehabilitation?
   c. What parts of climate change effects are mostly prioritised or is climate change prioritised wholesomely?

Theme 3: Firms views and awareness of climate change

1. Which phase of the mine lifecycle would climate change effects pose the highest threat?

2. Do you think restoration / rehabilitation will be significantly affected by climate change in the next 50 to 100 years?
   a. If yes, how important is it that the effects of climate change are considered in restoration / rehabilitation plans currently?
   b. If no, why not?
3. What do you think research on current rehabilitation / restoration should focus on for future projects (i.e. climate change as a whole or specifics such as water issues, temperature issues, CO₂ concentration etc.)?
   a. What type of institution would be appropriate to execute such research? Why?
   b. Would such research then need to be supported by legislative requirements for the mining sector to comply with?

4. What tools, presently available, could be used to incorporate and account for climate change effects?
   a. Are Environmental Impacts Assessments (EIAs), Strategic Environmental Assessments (SEAs) adequate tools to also inform climate change effects?

5. In general, will climate change affect the mining sector negatively or positively?
   a. Why?

Theme 4: Reviewing past and current examples

1. Are there any case studies on climate change and / or rehabilitation that I may review which further elaborate how mitigation/adaptation measures in light of climate change have been developed and implemented?
Appendix 1g: Academic questionnaire

**Questions that probe key areas of discussion: Academic institutions**

**Theme 1: Introducing the participant’s profession**

3. What is field of research are you in?
   a. What does your research entail?
   b. How long have you been involved in this research?

4. How does the research department you’re in influence government and mining companies?

**Theme 2: Views on mining clients/sector**

3. In your experience, what are the thoughts and views that most mining companies have towards climate change?
   a. Is there still too much uncertainty in the scientific reports for the companies to start taking precautionary measures in planning (e.g. environmental, financial, social etc.)?

4. What is the level of awareness towards climate change portrayed by the mining companies that you may have worked with?
   a. Is there more or less awareness in the rehabilitation phase of the mine lifecycle?
   b. Can you rate the extent to which climate change is of concern at rehabilitation?
   c. What parts of climate change effects are mostly prioritised or is climate change prioritised wholesomely?

**Theme 3: Firms views and awareness of climate change**

6. In your view, which phase of the mine lifecycle would climate change effects pose the highest threat?

7. Do you think restoration / rehabilitation will be significantly affected by climate change in the next 50 to 100 years?
   a. If yes, how important is it that the effects of climate change are considered in restoration / rehabilitation plans currently?
   b. If no, why not?
8. What do you think research on current rehabilitation / restoration should focus on for future projects (i.e. climate change as a whole or specifics such as water issues, temperature issues, CO₂ concentration etc.)?
   a. What type of institution would be appropriate to execute such research? Why?
   b. Would such research then need to be supported by legislative requirements for the mining sector to comply with?

9. What tools, presently available, could be used to incorporate and account for climate change effects?
   a. Are Environmental Impacts Assessments (EIAs), Strategic Environmental Assessments (SEAs) adequate tools to also inform climate change effects?

10. In general, will climate change affect the mining sector negatively or positively?
    a. Why?

**Theme 4: Reviewing past and current examples**

2. Are there any case studies on climate change and / or rehabilitation that I may review which further elaborate how mitigation/adaptation measures in light of climate change have been developed and implemented?
10.2 Appendix 2

Figure 10.1: (A1): An outline of the closure planning process as presented by the MMSD (adapted from Van Zyl et al. (2002b).
10.3 Appendix 3
Adaptation monitoring systems which consist of the 4Cs, adapted from Ford and Ford (2014)

Figure 10.2: (A2): Adaptation monitoring systems which consist of the 4Cs, adapted from Ford and Berrang-Ford (2015).
Appendix 4

JSE SRI Index list for the year 2013, with highlighted mining companies.

<table>
<thead>
<tr>
<th>2013 SRI Index Constituents (in alphabetical order)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Advtech Limited</td>
<td>Harmony Gold Mining Company Limited</td>
<td></td>
</tr>
<tr>
<td>AECI Limited</td>
<td>Illovo Sugar Limited</td>
<td></td>
</tr>
<tr>
<td>African Bank Investments Ltd</td>
<td>Impala Platinum Holdings</td>
<td></td>
</tr>
<tr>
<td>African Oxygen Limited</td>
<td>Imperial Holdings Ltd</td>
<td></td>
</tr>
<tr>
<td>African Rainbow Minerals Limited</td>
<td>Intu Properties</td>
<td></td>
</tr>
<tr>
<td>Allied Electronics Corporation Limited (Altron)</td>
<td>Investec (Ltd and plc)</td>
<td></td>
</tr>
<tr>
<td>Anglo American plc</td>
<td>JD Group</td>
<td></td>
</tr>
<tr>
<td>Anglo American Platinum Limited</td>
<td>JSE Limited</td>
<td></td>
</tr>
<tr>
<td>AngloGold Ashanti</td>
<td>KAP Industrial Holdings</td>
<td></td>
</tr>
<tr>
<td>ArcelorMittal South Africa</td>
<td>Kumba Iron Ore</td>
<td></td>
</tr>
<tr>
<td>Aspen Pharmacare Holdings Limited</td>
<td>Lewis Group Ltd</td>
<td></td>
</tr>
<tr>
<td>Barclays Africa Group Limited</td>
<td>Liberty Holdings Limited</td>
<td></td>
</tr>
<tr>
<td>Barloworld Limited</td>
<td>Lonmin plc</td>
<td></td>
</tr>
<tr>
<td>BHP Billiton</td>
<td>Massmart Holdings</td>
<td></td>
</tr>
<tr>
<td>The Bidvest Group Limited</td>
<td>Mediclinic International Limited</td>
<td></td>
</tr>
<tr>
<td>British American Tobacco</td>
<td>Merafe Resources</td>
<td></td>
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<tr>
<td>Business Connexion Group</td>
<td>MMI Holdings Ltd</td>
<td></td>
</tr>
<tr>
<td>Discovery Holdings Limited</td>
<td>Mondi (Ltd and plc)</td>
<td></td>
</tr>
<tr>
<td>DRDGOLD Limited</td>
<td>Mpact</td>
<td></td>
</tr>
<tr>
<td>Exxaro Resources</td>
<td>MTN Group Ltd</td>
<td></td>
</tr>
<tr>
<td>Firstrand Limited</td>
<td>Nampak</td>
<td></td>
</tr>
<tr>
<td>The Foschini Group Limited</td>
<td>Nedbank Ltd</td>
<td></td>
</tr>
<tr>
<td>Gold Fields Limited</td>
<td>Netcare Limited</td>
<td></td>
</tr>
<tr>
<td>Grindrod</td>
<td>Northam Platinum Limited</td>
<td></td>
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<tr>
<td>Growthpoint Properties</td>
<td>Oceana Group Limited</td>
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<table>
<thead>
<tr>
<th>2013 SRI Index Constituents (in alphabetical order) (continued)</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Old Mutual Plc</td>
<td>Santam Ltd</td>
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<tr>
<td>Pick n Pay Retailers (Pty) Ltd</td>
<td>Sappi Limited</td>
</tr>
<tr>
<td>PPC Limited</td>
<td>Sasol</td>
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<tr>
<td>Rainbow Chicken Limited</td>
<td>Sibanye Gold</td>
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<td>Redefine Properties</td>
<td>Standard Bank Group</td>
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<td>Remgro Limited</td>
<td>Steinhoff International</td>
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<td>Reunert</td>
<td>Sun International Ltd</td>
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<td>RMB Holdings</td>
<td>Tongaat Hulett</td>
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<tr>
<td>Royal Bafokeng Platinum Limited</td>
<td>Truworths International Limited</td>
</tr>
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<td>SAB Miller</td>
<td>Vodacom Group Limited</td>
</tr>
<tr>
<td>Santam</td>
<td>Woolworths International Holdings</td>
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</tbody>
</table>

Figure 10.3: (A3): JSE SRI Index list of companies listed for the year 2013, with the selected mining companies highlighted.
10.4 Appendix 5
Profile of interviewed candidates in mining companies, consulting firms as well as in academic institutions.

<table>
<thead>
<tr>
<th>Position</th>
<th>Department</th>
<th>Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vice President Environment and Sustainability Department</td>
<td>Environmental Matters</td>
<td>7 years</td>
</tr>
<tr>
<td></td>
<td>• Policy and Standards and Compliances</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Covers entire life cycle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Global accountability</td>
<td></td>
</tr>
<tr>
<td>Mine closure: Technical Requirements</td>
<td>Discipline for Technical, Assurance, Knowledge</td>
<td>17 years</td>
</tr>
<tr>
<td></td>
<td>• Integrating closure in mining lifecycle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Empowered</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Environment and Climate Change</td>
<td></td>
</tr>
<tr>
<td>Senior Environmental Manager</td>
<td>Corporate Headquarters</td>
<td>18 years</td>
</tr>
<tr>
<td></td>
<td>• Exploration, Projects, Acquisition</td>
<td></td>
</tr>
<tr>
<td>Unit Environmental Manager</td>
<td>Air quality and carbon</td>
<td>3 years</td>
</tr>
<tr>
<td>Head of Water, Waste and Environment</td>
<td>Environmental Matters</td>
<td>21 years</td>
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<tr>
<td></td>
<td>• Excludes air and</td>
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<tr>
<td></td>
<td>• Climate (adaptation)</td>
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</tr>
<tr>
<td>Principal Consultants</td>
<td>Air quality</td>
<td>7 years</td>
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<tr>
<td></td>
<td>• Climate change</td>
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</tr>
<tr>
<td></td>
<td>• Mine closure</td>
<td></td>
</tr>
<tr>
<td>Project Manager</td>
<td>Manages EIAs and mine closure as an interest</td>
<td>4 ½ years</td>
</tr>
<tr>
<td></td>
<td>• Permitting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Performance</td>
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<tr>
<td></td>
<td>• Legal</td>
<td></td>
</tr>
<tr>
<td>Principal consultant</td>
<td>Strategies around closure and financial with risk and cost quantification of risks</td>
<td>6 years</td>
</tr>
<tr>
<td></td>
<td>• Mine Closure and EMP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Contaminated Site Rehabilitation programmes</td>
<td></td>
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<tr>
<td></td>
<td>• Compliance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Environmental due diligence, assets and liabilities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sustainability and Climate Change</td>
<td></td>
</tr>
<tr>
<td>Role</td>
<td>Experience</td>
<td>Responsibilities</td>
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</tr>
</tbody>
</table>
| Consultant            | 4 years    | • Carbon footprint  
• Climate models  
• Regulatory requirements  
• Rehab and closure  
• Closure planning and costing  
• Environmental planning business unit |
| Retired researcher    | 35 years   | • Ecological Restoration in two South African Universities  
• Advise mining companies on damage and regaining work in Arid zone conservation and restoration.  
• Impact assessment and EMPs  
• Impact reduction, mitigation and restoration  
• Roads construction, Titanium mining |
| Researcher            | 10 years   | • Land use Change and Hydrology  
• Run off and recharge of water  
• Government consulting on  
• Climate change and Agriculture  
• Climate change and Mining |
### 10.5 Appendix 6

<table>
<thead>
<tr>
<th>Company</th>
<th>Climate change and rehabilitation issues</th>
<th>Strategic response measure(s)</th>
<th>Climate change and rehabilitation issues</th>
<th>Strategic response measure(s)</th>
<th>2013</th>
</tr>
</thead>
</table>
| **African Rainbow Minerals** | ● Data management  
● Carbon tax policy  
● Competitive risk (financial loss)  
● Reputational risks (lack of strategies to respond to climate change)  
● Physical risks (energy and water)  
● Integration of climate change response across business  
● Devise performance objectives, climate policy aligned with government and ICMM  
● Development of climate change strategy including cost and availability estimates (e.g. recycling, process optimisation)  
● Develop data management systems that are complete  
● Hire consultants  
● Up-skilling employees on climate change preparedness  
● BAPs  
● Data management  
● Carbon tax policy  
● Energy use, cost and production mechanisms  
● Water availability (operational productions)  
● Extreme weather events (physical risks such as storms)  
● Land management (biodiversity conservation, rehabilitation and closure planning)  
● Alien invasive species  | ● Formulation of climate change policy in line with national government legislation and the ICMM as well as performance objectives  
● Integration of climate change strategy in entire business processes  
● Scenario planning workshops, employee training, CDP reporting  
● Efficient use of diesel  
● Risk management process across all levels (good corporate governance)  
● Compile emission inventories and reduce energy consumption by increasing efficiency  
● Hire consultants  
● Independent specialists calculate rehabilitation and closure costs annually  
● BAPs  | ● Reputational issues  
● Carbon tax policy  
● Financial implications of climate change  
● Energy consumption  
● Water availability (limits production, limits business expansion)  
● Extreme weather events (storms, floods droughts)  
● Biodiversity loss  
● Waste rock disposal and potential ground water contamination  | ● Group strategy and policy on climate change and mitigation  
● Continue with the setting of performance objectives  
● Independent verification of CDP report  
● Workshops on climate change risks  
● Raise climate change awareness within business and surrounding areas.  
● Emission inventories  
● Water and energy use efficiency  
● Environmental management  
● Independent specialists used for rehabilitation and closure calculations and implementation  
● Financial provision for rehabilitation and closure  
● BAPs  |
| **Anglo American Platinum** | ● Carbon tax policy  
● GHG emissions  
● Energy supply  
● Water scarcity (business operations and communities)  
● Extreme events (droughts and floods)  
● Rehabilitation halted due to water surplus  
● Negative impact on biodiversity due to climate change  
● Communication with the government on the carbon tax  
● Already have a climate change strategy (aimed at improving short-term performance, 10 years)  
● Policy development and employment of adequately skilled people  
● Already have an energy policy  
● Reduce energy consumption and carbon emissions with new technologies  
● Improve water accessibility  | ● Legislative requirements  
● Threat to supply chain and distribution networks  
● Energy supply  
● Water supply  
● Low rainfall affecting aquatic life  
● Extreme events (threat on physical environment and assets)  | ● Integration into communication strategy  
● Reporting as part of the Carbon Disclosure Project (CDP)  
● Climate change strategy that aligns with life of mine (long term approach)  
● Signatory to energy efficiency standards by government  
● Project developed to display climate change projection, shows business risks and develops adaption measures  
● Collaborating with stakeholders  | ● Climate change adaption  
● Carbon emission costs  
● Energy  
● Water scarcity (situation of operations)  | ● Application of the mitigation hierarchy  
● Environmental excellence awards  
● Climate change strategy (carbon savings and economically sustainable energy)  
● Use of integrated risk methodology  
● Risks analysis both top-down and bottom-up approach  
● Rehabilitation used as a carbon offset  
● Annual revision of closure liability as of government legislation  |
<table>
<thead>
<tr>
<th>Company</th>
<th>Climate change and rehabilitation issues</th>
<th>Strategic response measure(s)</th>
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<th>Strategic response measure(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anglo American</td>
<td>GHG emissions</td>
<td>• Climate change strategy and policy</td>
<td>Carbon pricing</td>
<td>• Collaborations into new climate change policies</td>
<td>Carbon pricing</td>
<td>• Partake in governmental policy processes for the climate change agenda</td>
</tr>
<tr>
<td></td>
<td>Carbon pricing</td>
<td>• GHG emissions</td>
<td>• Energy consumption</td>
<td>• Investor, client and community engagement on carbon emissions</td>
<td>• Changing costs of energy and water</td>
<td>• Working with different stakeholders including government, academic institutions as well as private partnerships</td>
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<tr>
<td></td>
<td>Energy costs</td>
<td>• Engagement in climate change policy</td>
<td>• Water availability</td>
<td>• Climate change adaptation strategies</td>
<td>• Energy constraints</td>
<td>• Climate change strategy (multidisciplinary networks for climate change risk processing)</td>
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<tr>
<td></td>
<td>Water availability</td>
<td>• Mitigation hierarchy</td>
<td>• ARD</td>
<td>• Mitigation hierarchy</td>
<td>• Water availability and quality</td>
<td>• Mitigation hierarchy</td>
</tr>
<tr>
<td></td>
<td>Closure and rehabilitation costs</td>
<td>• Development of carbon and energy management programme</td>
<td>• Rehabilitation is both a regulator and financial risk</td>
<td>• Development of environmental performance standards</td>
<td>• Physical climate change impacts</td>
<td>• Carbon capture and storage technology</td>
</tr>
<tr>
<td></td>
<td>Physical climate change impacts</td>
<td>• Development of new technology (fuel cells)</td>
<td>• Rehabilitation operational risks: soil erosion, water pollution</td>
<td>• Research in the sharing of scarce natural resources</td>
<td>• Environmental incidents in rehabilitation</td>
<td>• Use of renewable energy</td>
</tr>
<tr>
<td></td>
<td>Acid Rock Drainage (ARD)</td>
<td>• Carbon capture and storage research</td>
<td>• Energy and carbon management programme</td>
<td>• Energy and carbon management programme</td>
<td>• ARD</td>
<td>• Water reclamation plant</td>
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<tr>
<td></td>
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<td>• Water management: Water efficiency target tool (WETT), Water Action Plans (WAPs) and use of geo-hydrological models</td>
<td>• Technologies to reduce carbon emissions (clean energy opportunities)</td>
<td>• Technologies to reduce carbon emissions (clean energy opportunities)</td>
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<td>• Adaptive water management</td>
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<tr>
<td></td>
<td></td>
<td>• Carbon capture and storage research</td>
<td>• Research on regional precipitation including volume, frequency and severity</td>
<td>• Research on regional precipitation including volume, frequency and severity</td>
<td></td>
<td>• Design mine with closure in mind</td>
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<tr>
<td></td>
<td></td>
<td>• Water management: Water efficiency target tool (WETT), Water Action Plans (WAPs) and use of geo-hydrological models</td>
<td>• Mine closure toolbox</td>
<td>• Mine closure toolbox</td>
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<td>• Mine closure toolbox</td>
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<td></td>
<td>• Water management: Water efficiency target tool (WETT), Water Action Plans (WAPs) and use of geo-hydrological models</td>
<td>• Concurrent rehabilitation</td>
<td>• Concurrent rehabilitation</td>
<td></td>
<td>• Future regional climate modeling</td>
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<tr>
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<td>• Water management: Water efficiency target tool (WETT), Water Action Plans (WAPs) and use of geo-hydrological models</td>
<td>• Introduction of BAPs</td>
<td>• Continuous contribution to financial provisioning for rehabilitation</td>
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<td>• Financial provision for decommissioning and rehabilitation</td>
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<tr>
<td></td>
<td></td>
<td>• MinE Closure Toolbox</td>
<td>• TSF dewatering technology to reduce seepage</td>
<td>• TSF dewatering technology to reduce seepage</td>
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<td></td>
<td></td>
<td>• Concurrent rehabilitation</td>
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<tr>
<td></td>
<td></td>
<td>• Introduction of BAPs</td>
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<tr>
<td>Company</td>
<td>Climate change and rehabilitation issues</td>
<td>Strategic response measure(s)</td>
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<td>Strategic response measure(s)</td>
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</tbody>
</table>
| Anglo Gold Ashanti | ● GHG emissions  
● Carbon pricing  
● Energy costs  
● Water availability  
● Closure and rehabilitation costs  
● Physical climate change impacts  
● Cyanide contamination | ● Strategy development for climate change, water security and energy consumption  
● Physical climate change risk assessment  
● Development of site level action plans which include operational and engineering solutions  
● Development of an Integrated Water Management system, piloted in South Africa | ● GHG emissions  
● Carbon pricing  
● Energy costs  
● Water availability  
● Closure and rehabilitation costs  
● Physical climate change impacts  
● Cyanide contamination  
● Water supply required for rehabilitation | ● Material issues classified as water supply, energy supply, physical and regulatory effects of climate change  
● Integrated Water Management system | ● Competition for resources due to energy shortages and climate change  
● Climate change to affect biodiversity  
● Business continuity to be affected by physical and financial implications of climate change | ● Biodiversity Management Standard  
● Climate change strategy  
● GHG emissions targets |
| BHP Billiton | ● Carbon tax policy (and other legislations)  
● Material risk profile (financial and reputational)  
● GHG emissions  
● Financial implications  
● Changes in investment environment  
● Energy consumption  
● Water constraints  
● Physical impacts (sea level rise, high temperatures)  
● Changing rainfall patterns (flooding and droughts)  
● Land degradation | ● Climate change policy development  
● Ascribe to international bodies for sustainability and carbon emissions trading  
● Engage in climate dialogues  
● Contributing to the public debate  
● Preparation for an industry of low carbon emissions  
● Mitigation hierarchy  
● Sustainability Framework (Environment and Community)  
● Use of renewable energy  
● Conservation projects  
● Management of land throughout lifecycle of the project  
● Development of closure plans for all business assets including financial provision (done annually)  
● Rehabilitate land to pre-mining land use or alternatively a land use agreed upon by all stakeholders | ● Greenhouse gas emissions  
● Carbon regulations  
● Productivity and financial constraints  
● Energy supply (use is high)  
● Water scarcity  
● Physical impacts (varying rainfall, increased storm events, high temperatures)  
● Land degradation | ● Participation in governmental debates in climate change  
● Setting of climate change policy development principles  
● GHG inventories  
● Implementation of water management systems and water accounting standards  
● Biodiversity and conservation targets  
● Closure plans for all assets with financial provision  
● Closure plan auditing | ● Legislative requirements  
● Productivity and financial constraints  
● GHG emissions and costs  
● Water scarcity  
● Physical impacts (varying rainfall, increased storm events, high temperatures, droughts, floods)  
● Accelerated ecosystem degradation | ● Climate change policy development principles  
● Internal carbon pricing protocol  
● Research on abatement opportunities  
● Land management plans  
● Closure planning with financial provision (with auditing)  
● Rehabilitation programmes planned with stakeholders  
● Developing areas of conservation  
● Employment in mine rehabilitation work |
| DeBeers | ● Carbon tax  
● Water scarcity  
● Energy security  
● Pollution prevention | ● Energy and Climate Vision Strategy  
● Best Practice Principles Assurance Programme  
● Six Environmental Standards (which include: lifecycle planning, | ● Review of financial provision for rehabilitation  
● Different forms of rehabilitation (e.g.  
● Climate Change research in collaboration with Worldwide Fund for Nature (WWF-South Africa) and the UNGC | ● Water scarcity  
● Mining activity exacerbating climate change | ● Environmental Management Systems (EMS)  
● Five-year Environmental Goal (risks; resources; rehabilitation and |
<table>
<thead>
<tr>
<th>Company</th>
<th>Climate change and rehabilitation issues</th>
<th>Strategic response measure(s)</th>
<th>Climate change and rehabilitation issues</th>
<th>Strategic response measure(s)</th>
<th>Climate change and rehabilitation issues</th>
<th>Strategic response measure(s)</th>
</tr>
</thead>
</table>
| **DRD Gold** | • Extreme weather events  
• Increasing energy costs  
• Water scarcity and groundwater contamination (AMD)  
• Physical impacts (floods, high rainfall, food insecurity, increased disease prevalence)  
• Strict rehabilitation laws  
• High rehabilitation costs | • Use of EMPs  
• Financial provision for closure and rehabilitation  
• Use of different rehabilitation methodologies which are vegetation, cladding, ridge ploughing etc.  
• Dedicated rehabilitation trust fund | • Dumpping, topsoil replacing, seedling and transplanting | • Six Environmental Standards (which include: lifecycle planning, biodiversity, water, climate change, pollution prevention/waste management and environmental reporting)  
• Prioritising climate change adaptation | • Increased cooling costs  
• Two different closure practices i.e. concurrent rehabilitation as well as post-production closure rehabilitation | **biodiversity; requirements and reporting; and reputation** |
| **Exxaro** | • GHG emissions  
• Energy shortages and increased costs  
• Water security and contamination  
• Physical impacts (floods, droughts, heat, supply chain disruptions)  
• Land degradation and contamination  
• Varying rehabilitation costs | • Compliance to environmental legislation  
• Climate change statement  
• Enhance green technology development  
• Collaborating with academic research institutions  
• Pilot studies of mitigation and adaptation strategies  
• Water management (development of water treatment and recycling facilities)  
• Continued review of rehabilitation plans  
• Financial provision for rehabilitation and decommissioning (annual) | • Environmental regulatory compliance  
• Carbon tax policy  
• GHG emissions  
• Energy availability and cost  
• Water scarcity and quality  
• Physical climate change impacts (floods, droughts, fires, heat)  
• Land degradation | • Compliance with legislative requirements  
• Energy and carbon management plan developed  
• Formulation of strategies to deal with extreme conditions  
• Use of an integrated business model  
• Water management programme (quality and quantity)  
• Investing in alternative renewable energy  
• Enhance environmental management projects  
• Updating company rehabilitation standards | • Environmental regulatory compliance  
• GHG emissions  
• Water scarcity  
• Land degradation | **Using reporting guidelines**  
**Compliance to legislative requirements**  
**Water management programmes**  
**Financial provision for closure (Rehabilitation trust fund)**  
**Continuous updating of the Environmental Management Programme (EMPR)** |
<table>
<thead>
<tr>
<th>Company</th>
<th>Climate change and rehabilitation issues</th>
<th>Strategic response measure(s)</th>
<th>Climate change and rehabilitation issues</th>
<th>Strategic response measure(s)</th>
<th>Climate change and rehabilitation issues</th>
<th>Strategic response measure(s)</th>
</tr>
</thead>
</table>
| Gold Fields | Carbon tax policy  
• Increased energy costs  
• GHG emissions  
• Water scarcity  
• Water contamination (AMD)  
• Physical impacts (flash floods, high temperatures, rain intensity)  
• Land degradation including waste rock | Carbon management policy  
(accounting and auditing)  
• Mitigate carbon pricing risks  
• Energy efficiency strategies  
• Climate mitigation and adaptation actions  
• Energy and carbon strategy plan  
• Water management programmes (for quality and quantity)  
• Research in rehabilitation and AMD  
• Concurrent rehabilitation  
• Trust fund for closure and rehabilitation provision  
• Biodiversity conservation (through Environmental Management Systems, EMS) | Carbon tax policy  
• Increasing energy costs  
• GHG emissions  
• Water scarcity and quality (e.g. AMD)  
• Erosion and water stagnation on waste sites  
• TSFs  
• Land degradation | Reporting using the carbon management plan  
• Development of renewable energy technologies  
• Water strategy (quality and quantity)  
• Environmental trust funds for rehabilitation  
• TSF inspection for technical stability  
• Environmental audits on TSFs  
• Change design feature of TSFs | Carbon tax policy  
• Reporting using the carbon management plan  
• Development of renewable energy technologies  
• Water strategy (quality and quantity)  
• Environmental trust funds for rehabilitation  
• TSF inspection for technical stability  
• Environmental audits on TSFs  
• Change design feature of TSFs | Generation of renewable energy  
• Short and long term water management strategies  
• Acid based accounting  
• Vegetation rehabilitation programmes |
| Harmony Gold | High fossil fuel use (causing GHGs)  
• Water availability  
• Mine underground water pumping  
• Land degradation  
• Contamination legacy issues (AMD) | Developmental policy on climate change  
• Development of national measures for GHG emissions  
• Water management (reduce freshwater use and re-use water)  
• Financial provision for rehabilitation (reviewed annually)  
• Implement a strategy on progressive rehabilitation (including concurrent rehabilitation)  
• Collaboration with other mining companies and the government to participate in public debates and policy initiatives on climate change  
• Climate change policy  
• Water management (reduce freshwater use and re-use water)  
• Increasing energy efficiency thus reducing emissions  
• Exploration of renewable energy  
• Rehabilitation as a carbon offset strategy for bio-energy  
• Constant reviews of performance standards in water management, climate change, rehabilitation, closure etc. | Carbon tax policy  
• GHG emissions  
• Energy consumption  
• Water scarcity due to limited rainfall (especially groundwater)  
• Physical climate change impacts (high storm intensity, long wet and dry periods, high and low temperatures) | Participation in public debates and policy initiatives on climate change  
• Climate change policy  
• Water management (reduce freshwater use and re-use water)  
• Increasing energy efficiency thus reducing emissions  
• Exploration of renewable energy  
• Rehabilitation as a carbon offset strategy for bio-energy  
• Constant reviews of performance standards in water management, climate change, rehabilitation, closure etc. | Carbon tax policy  
• GHG emissions  
• Energy consumption  
• Land degradation  
• Physical impacts (floods)  
• Contamination of soils and water (AMD) | Work with government on legislative policies  
• Climate change policy  
• Promote energy efficiency projects  
• Water management (reduce freshwater use and re-use water, create a closed loop water system)  
• Financial provision for closure and rehabilitation (reviewed annually)  
• Implement a strategy on progressive rehabilitation (including concurrent rehabilitation) |
<table>
<thead>
<tr>
<th>Company</th>
<th>Climate change and rehabilitation issues</th>
<th>Strategic response measure(s)</th>
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<th>Strategic response measure(s)</th>
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</thead>
<tbody>
<tr>
<td><strong>Impala</strong></td>
<td>- Carbon tax policy</td>
<td>- Development of Carbon management strategy</td>
<td>- Carbon tax policy</td>
<td>- Increasing costs for resource use</td>
<td>- Partnerships with government to deliver resources</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- GHG emissions (increasing carbon footprint)</td>
<td>- Report on upstream and downstream carbon footprints</td>
<td>- GHG emissions</td>
<td>- GHG emissions</td>
<td>- Participation in international and national debates and policy development on climate change</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Energy consumption and increased costs</td>
<td>- Fuel cell innovation</td>
<td>- High energy use</td>
<td>- High energy use</td>
<td>- Climate change response strategy</td>
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<tr>
<td></td>
<td>- Water availability</td>
<td>- GHG abatement mechanism</td>
<td>- Water scarcity</td>
<td>- Water scarcity</td>
<td>- Carbon management strategy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Physical impacts of climate change (drought, floods, increased costs)</td>
<td>- Quantification of carbon footprint</td>
<td>- Land degradation</td>
<td>- Land degradation</td>
<td>- Development of energy efficiency projects</td>
<td></td>
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<tr>
<td></td>
<td>- Changing weather patterns (in relation to the health issues of the community)</td>
<td>- Water management (quality and quantity)</td>
<td>- Physical impacts of climate change (drought, floods, increased costs)</td>
<td>- Physical impacts of climate change (drought, floods, increased costs)</td>
<td>- Collaboration with government and academic institutions for research on renewable energy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Land degradation</td>
<td>- Introduction of energy efficient technologies</td>
<td>- Potential opportunity to avoid carbon intensive economy</td>
<td>- Introduction of energy efficient technologies</td>
<td>- Water stewardship and management (quality and quantity)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Future use of carbon-neutral biomass</td>
<td>- Participate in different discussions with government and other organisations</td>
<td>- Water conservation management strategy (quality and quantity)</td>
<td>- Air quality plan</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Align rehabilitation with governmental expectations</td>
<td>- Ensure sustainable rehabilitation programmes are implemented</td>
<td>- Ensure sustainability rehabilitation programmes are implemented</td>
<td>- Rehabilitation in line with EMPs and with approved rehabilitation plan</td>
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<tr>
<td></td>
<td></td>
<td>- Community engagement in rehabilitation</td>
<td>- Concurrent rehabilitation using EMPs</td>
<td>- Financial provision for closure and rehabilitation</td>
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<td></td>
<td></td>
<td>- Development of good rehabilitation plans</td>
<td>- Implement BAPs</td>
<td>- Concurrent rehabilitation using EMPs</td>
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</tr>
</tbody>
</table>

For **Platinum**:

- Research into current contamination levels and appropriate rehabilitation techniques
- Soil erosion and rainfall runoff
- Land degradation and footprint expansion
- TSFs and leachates
- Contamination of soils and water (AMD)
- Implement a strategy on progressive rehabilitation (including concurrent rehabilitation
- BAPs
- Planning of rehabilitation programmes

- Increasing costs for resource use
- GHG emissions
- High energy use
- Water scarcity
- Land degradation

Future use of carbon-neutral biomass
- Align rehabilitation with governmental expectations
- Community engagement in rehabilitation
- Development of good rehabilitation plans

- Implementation of Carbon management strategy (with risks and opportunities)
- Align strategies with national best practice standards and comply with legislations
- Potential opportunity in less carbon intensive economy
- Participate in discussions with government and other organisations
- GHG abatement equipment
- Carbon reduction targets
- Calculation of carbon footprint
- Introduction of energy efficient technologies
- Water conservation management strategy (quality and quantity)
- Ensure sustainable rehabilitation programmes are implemented
- Financial provision for closure and rehabilitation
- Concurrent rehabilitation using EMPs
- Implement BAPs

- Partnerships with government to deliver resources
- Participation in international and national debates and policy development on climate change
- Climate change response strategy
- Carbon management strategy
- Development of energy efficiency projects
- Collaboration with government and academic institutions for research on renewable energy
- Water stewardship and management (quality and quantity)
- Air quality plan
- Rehabilitation in line with EMPs and with approved rehabilitation plan
<table>
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<th>Company</th>
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<tbody>
<tr>
<td><strong>Kumba Iron Ore</strong></td>
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<td></td>
<td>• Carbon tax policy</td>
<td>• Collaborating with government and other industry leaders in the policy development</td>
<td>• GHG emissions</td>
<td>• Implementation of climate change strategy</td>
<td>• GHG emissions</td>
<td>• Employment of climate change strategy</td>
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<tr>
<td></td>
<td>• GHG emissions</td>
<td>• Implementation of the phase based climate change strategy</td>
<td>• Financial implications of climate change</td>
<td>• Regional climate change adaptation research</td>
<td>• Regional climate change adaptation research and quantification</td>
<td>• Regional climate change adaptation research and quantification</td>
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<tr>
<td></td>
<td>• Financial implications of climate change</td>
<td>• Regional climate change adaptation research</td>
<td>• Energy consumption</td>
<td>• Physical impacts (e.g. high rainfall, high temperatures and increased evaporation)</td>
<td>• Carbon offsets by planting appropriate vegetation for sequestration</td>
<td>• Carbon offsets by planting appropriate vegetation for sequestration</td>
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<tr>
<td></td>
<td>• Energy consumption</td>
<td>• Physical impacts (e.g. high rainfall, high temperatures and increased evaporation)</td>
<td>• Physical impacts</td>
<td>• Waste production and dump</td>
<td>• Waste production and dump</td>
<td>• Waste production and dump</td>
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<tr>
<td></td>
<td>• Large carbon footprint</td>
<td>• Implementation of carbon offsets</td>
<td>• Reduced dependency on fossil fuel based energy production</td>
<td>• Effective implementation of rehabilitation programmes informed by EMPs and BAPs</td>
<td>• Water management strategies (e.g. reservoir construction, target tool etc.)</td>
<td>• Proactive strategy in rehabilitation planning</td>
</tr>
<tr>
<td></td>
<td>• Water scarcity and poor quality</td>
<td>• Development of rehabilitation trust fund and conducting of concurrent rehabilitation</td>
<td>• Water management (harvesting rain water)</td>
<td>• Rehabilitation trust fund</td>
<td>• Rehabilitation trust fund for concurrent rehabilitation too (using EMPs and BAPs)</td>
<td>• Rehabilitation trust fund for concurrent rehabilitation too (using EMPs and BAPs)</td>
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<td></td>
<td>• Physical impacts (e.g. storms)</td>
<td>• Natural rehabilitation strategies such as phytoremediation and bioremediation</td>
<td>• Water management (harvesting rain water)</td>
<td>• Land degradation</td>
<td>• Shaping of TSFs</td>
<td>• Shaping of TSFs</td>
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<tr>
<td></td>
<td>• Land degradation</td>
<td>• Rehabilitation trust fund and conducting of concurrent rehabilitation</td>
<td>• Development of rehabilitation trust fund and conducting of concurrent rehabilitation</td>
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<td>• Biodiversity loss</td>
<td>• Rehabilitation trust fund and conducting of concurrent rehabilitation</td>
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<td>• Carbon tax policy</td>
<td>• Use of the precautionary principle</td>
<td>• Regulatory environment</td>
<td>• Regulatory environment (e.g. Carbon tax policy)</td>
<td>• Regulatory environment (e.g. Carbon tax policy)</td>
<td>• Regulatory environment (e.g. Carbon tax policy)</td>
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<tr>
<td></td>
<td>• GHG emissions</td>
<td>• Participation in local and international organisations and also government on climate change and policy development</td>
<td>• GHG emissions</td>
<td>• Pro-active environmental management</td>
<td>• Pro-active environmental management</td>
<td>• Pro-active environmental management</td>
</tr>
<tr>
<td></td>
<td>• Increased costs of resources (energy and water)</td>
<td>• Adoption of best technologies for GHG emissions reduction</td>
<td>• Increased costs of resources (energy and water)</td>
<td>• Risk identification database</td>
<td>• Risk identification database</td>
<td>• Risk identification database</td>
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<tr>
<td></td>
<td>• Energy supply</td>
<td>• Development of climate change response strategy</td>
<td>• Energy supply</td>
<td>• Calculation of carbon footprint</td>
<td>• Calculation of carbon footprint</td>
<td>• Calculation of carbon footprint</td>
</tr>
<tr>
<td></td>
<td>• Water security and availability (especially freshwater)</td>
<td>• Understanding of carbon footprint</td>
<td>• Water insecurity and availability (especially freshwater)</td>
<td>• Efficient use of energy</td>
<td>• Efficient use of energy</td>
<td>• Efficient use of energy</td>
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<tr>
<td></td>
<td>• Water contamination (especially groundwater)</td>
<td>• Comply with local legislation on air quality</td>
<td>• Physical impacts (droughts, floods, extreme weather events)</td>
<td>• Research funding for renewable energy and water management</td>
<td>• Research funding for renewable energy and water management</td>
<td>• Research funding for renewable energy and water management</td>
</tr>
<tr>
<td></td>
<td>• Physical impacts (floods, high temperatures, high evaportranspiration, droughts, hail etc.)</td>
<td>• Development of integrated water balance and general management for all operations (improve process efficiency, prevent contamination)</td>
<td>• Dormant TSFs</td>
<td>• Monitoring of water and electricity consumption (optimising consumption, minimising contamination, recycle and storage)</td>
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</tr>
<tr>
<td></td>
<td>• Land degradation</td>
<td>• Dormant TSFs</td>
<td>• Water management strategies (e.g. target tool)</td>
<td>• Restoration verification process by external parties</td>
<td>• Restoration verification process by external parties</td>
<td>• Restoration verification process by external parties</td>
</tr>
</tbody>
</table>

**Notes:**
- EMPs: Environmental Management Plans
- BAPs: best available practices
- TSFs: tailing storage facilities

**Key Issues:**
- Climate change and physical impacts (floods, droughts, extreme weather)
- Land degradation and water contamination
- Biodiversity loss and pollution
- Water scarcity and poor availability (especially groundwater)
- Increased costs of resources (energy and water)
- Energy consumption and increased evaporation
- Regional climate change adaptation research
- GHG emissions and energy consumption
- Physical impacts (e.g. high rainfall, high temperatures and increased evaporation)
- Waste production and dump
- Effective implementation of rehabilitation programmes informed by EMPs and BAPs
- Water management strategies (e.g. reservoir construction, target tool etc.)
- Proactive strategy in rehabilitation planning
- Rehabilitation trust fund for concurrent rehabilitation too (using EMPs and BAPs)
- Shaping of TSFs
- Use of vegetation and bacteria for remediation
- Proactive strategy in rehabilitation (using EMPs and BAPs)
- Regular review of rehabilitation programmes to be implemented
- Rehabilitation trust fund and conducting of concurrent rehabilitation (using EMPs and BAPs)
- Environmental impacts (e.g. carbon footprint, classification of GHGs.)
- Energy conservation plans (improve efficiency)
- Water management strategies (e.g. reservoir construction, target tool etc.)
- Sustainable, effective and natural rehabilitation programmes
- Participate in governmental feedbacks on climate change policy
- Cost management of climate change impacts
- Risk management of environmental impacts
- Calculation of carbon footprint and classification of GHGs.
- Amendment of energy strategy
- Increase energy efficiency in operations and reduce water use
- Water management project
- EMPs and BAPs use for rehabilitation to enhance conservation efforts
<table>
<thead>
<tr>
<th>Company</th>
<th>Climate change and rehabilitation issues</th>
<th>Strategic response measure(s)</th>
<th>Climate change and rehabilitation issues</th>
<th>Strategic response measure(s)</th>
<th>Climate change and rehabilitation issues</th>
<th>Strategic response measure(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northam Platinum</td>
<td>• Loss of biodiversity</td>
<td>• Reduce the dependency on coal produced electricity</td>
<td>• Contamination of soil and water</td>
<td>• Monitoring of rehabilitation (especially water quality, and vegetation establishment)</td>
<td>• Land degradation and soil and water contamination</td>
<td>• Collaboration with research institutions and organisation to address the invasion of alien species</td>
</tr>
<tr>
<td></td>
<td>• Regulatory policies</td>
<td>• BAPs and EMPs used for rehabilitation (phytoremediation and bioremediation)</td>
<td>• Land and soil degradation</td>
<td>• Different rehabilitation techniques (phytoremediation and bioremediation)</td>
<td>• Biodiversity loss</td>
<td>• Monitoring of rehabilitation (especially water quality, and vegetation establishment)</td>
</tr>
<tr>
<td></td>
<td>• GHG emissions</td>
<td>• Biodiversity loss</td>
<td>• Biodiversity loss</td>
<td>• Community development project in removal of alien invasive species</td>
<td>• Land degradation and soil and water contamination</td>
<td>• Transparency in rehabilitation process</td>
</tr>
<tr>
<td></td>
<td>• Energy consumption and related costs</td>
<td>• Alien species invasion</td>
<td>• Alien species invasion</td>
<td>• BAPs and EMPs use for rehabilitation to enhance conservation efforts</td>
<td>• Biodiversity loss</td>
<td>• Closure strategy continuously updated</td>
</tr>
<tr>
<td></td>
<td>• Water availability and quality</td>
<td>• Physical risks of climate change</td>
<td>• Water availability and quality</td>
<td>• Water availability and quality</td>
<td>• Land degradation and soil and water contamination</td>
<td>• Collaboration with research institutions and organisation to address the invasion of alien species</td>
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<td></td>
<td>• Physical risks of climate change</td>
<td>• Biodiversity loss</td>
<td>• Physical risks of climate change</td>
<td>• Land degradation and soil and water contamination</td>
<td>• Biodiversity loss</td>
<td>• Monitoring of rehabilitation (especially water quality, and vegetation establishment)</td>
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<td></td>
<td>• Biodiversity loss</td>
<td>• Land degradation</td>
<td>• Land degradation</td>
<td>• Biodiversity loss</td>
<td>• Land degradation and soil and water contamination</td>
<td>• Transparency in rehabilitation process</td>
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<tr>
<td></td>
<td>• Land degradation</td>
<td>• TSFs drying</td>
<td>• TSFs drying</td>
<td>• Land degradation and soil and water contamination</td>
<td>• Biodiversity loss</td>
<td>• Closure strategy continuously updated</td>
</tr>
<tr>
<td>Royal Bafokeng Platinum</td>
<td>• Carbon tax policy</td>
<td>• Compliance with legislative requirements</td>
<td>• Regulatory environment</td>
<td>• Compliance with governmental regulations</td>
<td>• Financial implications</td>
<td>• Adherence to governmental policies and legislation</td>
</tr>
<tr>
<td></td>
<td>• GHG emissions</td>
<td>• Climate change strategy (has mitigation measures)</td>
<td>• Financial implications</td>
<td>• Engagement with public and private sector organisations and government institutions as stakeholders</td>
<td>• GHG emissions</td>
<td>• Hold public participation meetings to discuss challenges</td>
</tr>
<tr>
<td></td>
<td>• Energy consumption</td>
<td>• Participation and communication with many public and private sector stakeholders</td>
<td>• GHG emissions</td>
<td>• Climate change mitigation strategy</td>
<td>• Water consumption and quality</td>
<td>• Reporting on progress</td>
</tr>
<tr>
<td></td>
<td>• Financial implications</td>
<td>• Implement energy conservation strategies and energy management system</td>
<td>• Energy consumption</td>
<td>• Development of integrated water and waste management plan (recycling, quality checks, reporting)</td>
<td>• Water availability and quality</td>
<td>• Energy conservation (through energy efficient technologies)</td>
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<tr>
<td></td>
<td>(energy production)</td>
<td>• Water management (closed circuit system, rain recharge, quality checks)</td>
<td>• Water availability and quality</td>
<td>• Implementation of the Air Quality Act</td>
<td>• Land management</td>
<td>• Integrated water use management strategy (groundwater and surface water)</td>
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<tr>
<td></td>
<td></td>
<td>• Conduct specialists studies</td>
<td>• Physical risks of climate change</td>
<td>• Dust monitoring</td>
<td>• Biodiversity conservation</td>
<td>• Water awareness campaigns (quality and quantity)</td>
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<tr>
<td></td>
<td></td>
<td>• Development of land management strategies</td>
<td>• Land degradation</td>
<td>• Monitor water discharges</td>
<td>• Literature surveys (biotic surveys, alien vegetation removal)</td>
<td>• Dust management strategies (vegetation establishment)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Establishment of a rehabilitation trust fund</td>
<td>• TSFs drying</td>
<td>• Financial provision for rehabilitation and closure</td>
<td>• Known carbon footprint</td>
<td>• Financial provision for rehabilitation through a trust fund</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Biodiversity conservation initiatives through establishment of a conservation trust fund</td>
<td>• Compliance with regulatory regulations</td>
<td>• Land management</td>
<td>• Carbon tax policy</td>
<td>• Use of specialists for assessments</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Engagement with public and private sector organisations and government institutions as stakeholders</td>
<td>• Biodiversity conservation</td>
<td>• GHG emissions</td>
<td>• Concurrent rehabilitation</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>• Climate change mitigation strategy</td>
<td>• Financial provision for rehabilitation and closure</td>
<td>• Financial implications</td>
<td>• Biodiversity conservation (biotic surveys, alien vegetation removal)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Development of integrated water and waste management plan (recycling, quality checks, reporting)</td>
<td>• Conducting of a climate change risk assessment</td>
<td>• Energy production</td>
<td>• Risk and vulnerability assessment on climate change</td>
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<td></td>
<td></td>
<td>• Implementation of the Air Quality Act</td>
<td>• Development of energy efficient technologies</td>
<td>• Carbon tax policy</td>
<td>• Risk management model</td>
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<td></td>
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<td>• Dust monitoring</td>
<td>• Known carbon footprint</td>
<td>• GHG emissions</td>
<td>• Data management resource systems</td>
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<td></td>
<td></td>
<td></td>
<td>• Monitor water discharges</td>
<td>• Carbon tax policy</td>
<td>• Financial implications</td>
<td>• Collaboration with other stakeholders (industry participants)</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>• Financial provision for rehabilitation and closure</td>
<td>• GHG emissions</td>
<td>(energy production)</td>
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<tr>
<td>Company</td>
<td>Climate change and rehabilitation issues</td>
<td>Strategic response measure(s)</td>
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<tr>
<td>2011</td>
<td>Resource management (water and energy)</td>
<td>Water scarcity (floods, storms, droughts)</td>
<td>Waste management</td>
<td>Water management (treatment plants, run-off water conservation)</td>
<td>Limited resources (water scarcity and energy production)</td>
<td>and government ) on climate change assessment and risk management</td>
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<td></td>
<td>Water scarcity</td>
<td>Physical impacts</td>
<td>Biodiversity loss</td>
<td>Waste management</td>
<td>Annual carbon footprint assessment</td>
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<td>Physical impacts (floods, storms, droughts)</td>
<td>Assessment of carbon footprint</td>
<td>Waste production</td>
<td>Biodiversity and land management (units for management)</td>
<td>Energy reduction projects</td>
<td>and government ) on climate change assessment and risk management</td>
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<tr>
<td></td>
<td>Land degradation</td>
<td>Reduction in the use of fossil fuels</td>
<td>Land degradation</td>
<td>Financial provision for rehabilitation through a rehabilitation trust fund (reviewed annually)</td>
<td>Water management</td>
<td>Environmental implications</td>
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<td></td>
<td>Waste management</td>
<td>Application for water treatment plant installation (quality)</td>
<td>Biodiversity loss</td>
<td>BAPs (alien plant, fire, natural resource use, environmental education)</td>
<td>Waste management plan</td>
<td>and government ) on climate change assessment and risk management</td>
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<td></td>
<td>Biodiversity loss</td>
<td>Water management plans</td>
<td>Waste management plan</td>
<td>Waste management</td>
<td>Waste management</td>
<td>Environmental implications</td>
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<td>2012</td>
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<td>Waste management</td>
<td>Environmental implications</td>
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<td>Waste management plan</td>
<td>Waste management</td>
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<td>Waste management</td>
<td>Waste management</td>
<td>Environmental implications</td>
</tr>
<tr>
<td>Sasol</td>
<td>Development of climate change structure aligned to government policies</td>
<td>Non-compliance with legislation</td>
<td>Development of climate change structure aligned to government policies</td>
<td>Non-compliance with legislation</td>
<td>Development of climate change structure aligned to government policies</td>
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</tbody>
</table>
| Sibanye Gold | • Carbon tax policy  
• Increased energy costs  
• GHG emissions  
• Water scarcity  
• Water contamination (AMD)  
• Physical impacts (flash floods, high temperatures, rain intensity)  
• Land degradation including waste rock | • Carbon management policy (accounting and auditing)  
• Mitigate carbon pricing risks  
• Energy efficiency strategies  
• Climate mitigation and adaptation actions  
• Energy and carbon strategy plan  
• Water management programmes (for quality and quantity)  
• Research in rehabilitation and AMD  
• Concurrent rehabilitation  
• Trust fund for closure and rehabilitation provision  
• Biodiversity conservation (through Environmental Management Systems, EMS) | • Carbon tax policy  
• Increasing energy costs  
• GHG emissions  
• Water scarcity and quality (e.g. AMD)  
• Erosion and water stagnation on waste sites  
• TSFs  
• Land degradation | • Reporting using the carbon management plan  
• Development of renewable energy technologies  
• Water strategy (quality and quantity)  
• Environmental trust funds for rehabilitation  
• TSF inspection for technical stability  
• Environmental audits on TSFs  
• Change design feature of TSFs | • GHG emissions  
• Financial implications of climate change  
• Contamination (land, soil and water)  
• Dust pollution  
• Land degradation  
• Biodiversity loss | • Financial provision for rehabilitation  
• Rehabilitation programmes |

- Use of renewable energies and less carbon intensive energies (e.g. natural gas)  
- Water conservation and stewardship management with stakeholders (pre-treatment, recycling, supply, reliability, quality etc.)  
- Financial provisions for remediation  
- Biodiversity and ecosystem conservation

- Signatories to water conservation efforts  
- Implementation and strengthening of water management strategies (reduce and recycle)  
- Changes in mining techniques to minimise footprint  
- Risk development programme  
- Rehabilitation programmes  
- Biodiversity conservation through EIAs and EMPs

- Financial provision for rehabilitation  
- Rehabilitation programmes

- Carbon management policy (accounting and auditing)  
- Mitigate carbon pricing risks  
- Energy efficiency strategies  
- Climate mitigation and adaptation actions  
- Energy and carbon strategy plan  
- Water management programmes (for quality and quantity)  
- Research in rehabilitation and AMD  
- Concurrent rehabilitation  
- Trust fund for closure and rehabilitation provision  
- Biodiversity conservation (through Environmental Management Systems, EMS)
Reports for African Rainbow Minerals

*Report for 2011 (GRI G3 Self-declaration Application Level A+)*

Climate change was considered in the sustainable development model under the environmental pillar, which shows the environmental and economic risks. It is thus integrated into the overall governance strategy. The mentioned climate change issues are mostly directed to the operational phase of the mine lifecycle. Although floods are considered to be a physical risk, this is only to items that the company distinguishes as assets. The company does however mention that climate change will result in both flooding and droughts which may possibly affect the business at numerous levels. Additionally, the company conducts baseline studies to determine landscape characteristics such as soil erosion potential, soil quality and landscape functionality. Thus this, although indirectly, may be alluding to identify certain environmental conditions that may subsequently affect the aforementioned land characteristics. Climate change is seen as an additional material risks adding on to the already identified land management, biodiversity, rehabilitation and closure planning components. The company appears to consider climate change and rehabilitation as two different environmental components which do not influence each other. Rehabilitation and closure costs are calculated by independent specialists and annual inputs are made into the closure financial account. There also seems to be a gap in that the company acknowledges that climate change will affect water availability and also that rehabilitation is affected by water availability and quality; however, the link between climate change and rehabilitation is not explicitly made.

*Report for 2012 (GRI G3 Self-declaration Application Level A+)*

All issues that pertain to climate change and rehabilitation are incorporated into the company’s strategy, governance framework and risk management system; however, these are seen as being mutually exclusive. The company acknowledges that the nature of their business results in negative natural impacts thus rehabilitation is among some of the items to be effectively executed as a duty to the company. Additionally, climate change is also regarded as a significant risk to the company. In line with the second ICMM principle, the company reiterates that it follows sustainability principles throughout all the mine lifecycle phases, where interestingly, rehabilitation precedes closure as they mention the chronological sequence of events and phases. The company also
prides itself in implementing the environmental management systems (ISO 14001 certified) for activities such as rehabilitation as well as placing climate change as one of the top Group Risks. In some mining areas, rehabilitation is done concurrently with consultation of the specialists as well as the baseline EMPR. Great transparency is estimated closure costs where in some instances, using the precautionary principle, costs estimates are very much above the actual cost. Rehabilitation is informed by baseline EMPR studies, which among the characteristics look at soil erosion potential, landscape functionality and watershed management). Climate change perceived as both an economic and environmental issue.

**Report for 2013 (GRI G3 Self-declaration Application Level A+)**

In addressing the material issues of the company, which include climate change and rehabilitation, among the many other inputs, the company develops risk management processes, strives for alignment with best practice guidelines, as well as observes the regulator trends. In this report, the company has further explicitly mentioned in which operational areas water availability would be the highest constraint thus this shows some level of research that has been done in continuing sustainability reporting. Climate change is still regarded as the highest and most significant material risk with a non-financial impact; where land use management issues such as rehabilitation are other environmental issues. Although impacts of climate change are classified to be non-financial, it is important to note that the company acknowledges that the carbon tax will be placing a financial implication on impacts seen to be non-financial. Rehabilitation meets the second ICMM principle of sustainable development as well as the sixth ICMM principle on continued environmental performance where within also this principle climate change is mentioned as one of the areas to promote environmental performance. The company also acknowledges that failing to plan accordingly for climate change implications will result in reputational setbacks among other negative impacts. In comparing this report to the other two previous ones, climate change information appears to be more structured and flows well also showing a better understanding of the impacts that will be.
Reports for Anglo American Platinum

SD Report for 2011 (GRI G3 Self-declaration Application Level A+)

The company does look at climate change in general business decisions. According to a Mega Trends risk framework developed by the company, climate change is seen by both the company and stakeholders as a high risk in the economic environment as well as in the accessibility of resources. Climate change is the only trend that is regarded to have two high risk areas as opposed to the other Mega Trends which are urbanization, political risk and foreign exchange. Rehabilitation is not just seen as the restoration of the natural environment in which mining activities occurred but is also seen as a human resource development. Company acknowledges that climate change impacts affect both the company directly and indirectly through the community. The company also sees an opportunity in climate change where it could possibly open up a market in less carbon emitting energy alternatives. Interestingly, the company reports that rehabilitation has been halted at one of the mining operations due to a surplus of water. In all cases climate change is discussed in light of energy issues with carbon emissions etc.

Report for 2012 (GRI G3 Self-declaration Application Level A+)

Power supply, water supply and legislative changes are seen as a high risk in the sustainability of the business; however, this is not discussed in light of climate change. The company acknowledges that it is important to pay attention to all types of risks (high/low, significant/insignificant) as ultimately these may lead to larger risks that are not anticipated. The company also aims for a sustainable post mining land use beneficial to both the environment and the community. In discussing issues of climate change and energy governance, the company states that climate change is a long term issue just as much as the life of mine, which is a good starting point. Although the company does place climate change as a significant risk where among these are floods and droughts, the company has not set any targets to deal with such. The only targets that are seen are to reduce carbon emissions. Additionally, the company states that since climate change is a major challenge it aims to improve the resilience of assets, so now would rehabilitation constituents be regarded as assets? This company also regards closure as the final step mining where rehabilitation is done before closure.
There is no mention of floods and droughts within this report. Even though water issues such as availability and use of portable water is raised within the report, interestingly, water is not mentioned within the sphere of climate change. This may be because the company already sees that water availability is already a problem and thus climate change may not significantly affect water resources. The company presents seven external drivers of sustainability among them are climate change which is said to affect the carbon costs as well as adaption strategies and also population growth and urbanization which is said to affect natural resources such as land water and energy. The company however fails to explicitly link stresses on natural resources to climate change as climate change will place an additional burden on these resources. Not apparent in the previous reports, the five capitals model is resented showing the numerous challenges within each capital where climate change is placed with the natural capital. Unlike the 2012 report, in presenting its targets, the company states that it aims to look at how it is influencing climate change and also how climate change is affecting the company. This may be seen as a slight progression towards what is really required; however, still the company fails to mention droughts and floods in any of the targets as all of them are based carbon emissions. Even with an incident of low rainfall which led to aquatic life dying, the company fails to see that climate change, which may potentially exacerbate the currently seen dynamics will pose a serious threat to not only the rehabilitation phase but also the community as a whole. There are also many benefits associated with the climate change strategy where some are a better resilience to physical impacts, reduction risk to carbon tax, partake in government policy formulations.

Reports for Anglo American

Climate change and water were placed to be the major material business concerns hindering sustainability, especially because most operations operate in water scarce areas and also climate change issues relate to carbon emissions and financial implications of this. In its efforts to optimise operational excellence, the company prioritises water security together with climate change among the five drivers. Water issues are an important factor as climate change is thought to potentially
exacerbate the current conditions of water stressed areas and thus the company acknowledges that competition for water resources is likely to increase. In addition to the other numerous societal problems that the company faces especially in developing regions, climate change is mentioned with careful emphasis being placed on the uncertainty it also brings with it. Although the company does mention that climate change may pose physical risks but there is no specific mention of floods, storm, and droughts as potential consequences of climate change that may arise.

**Report for 2012 (GRI G3 Self-declaration Application Level A+)**

Climate change is considered to be central in keeping the business performance good. Climate change is also considered as one of the six sustainability areas that need to be addressed, but this specifically relates to energy and carbon emissions. In comparison to SD4 of 2011 where climate change and water issues appeared to be interlinked, the 2012 report shows that climate change issues are more associated with energy issues. The company firmly believes in responsible and sustainable mine closure and rehabilitation where rehabilitation is recommended to take place concurrently to operations. Similarly to SD4 of 2011, the company does appreciate that climate change will potentially cause physical impacts; however, these are not explicitly described (including floods, storms or droughts). Furthermore, the current uncertainty with climate change contributes to the company not taking many long-term strategies but rather focusing on short-term strategies which will also give them a competitive advantage. By participating in the public climate change debates, the company hopes to contribute to good policy formulations that will also enhance their business performance. The company has also devised a timeline in which it will meet carbon measures where within the different timeframes mitigation and adaptation measures are developed and embedded in general risk management after the regional climate change impacts have been identified.

Rehabilitation is highly valued especially in order to enhance social and environmental performance. Rehabilitation related work is discussed during the environmental assessment process.

**Report for 2013 (GRI G4 guideline standards)**

The company has identified a total of eight material issues within the business, and South Africa hosts seven of those eight, one of them being climate change and water issues. The company aims to be a responsible mining house with minimal environmental consequences and thus closure
plans are continuously updated to suit the developments in the region. One of the aims of the company is to develop great resilience to the climate change impacts. The timelines to achieving carbon neutrality are further divided into three phases for the company to implement over a ten year period. Considering the long life of mine that the company anticipates in most of its operations it recognizes that climate change will be a serious business risk as climate change will occur in the long term. Rehabilitation planning involves the different stakeholders and is carried out using global environmental standards. In addition to this, the company has ascribed to numerous rehabilitations societies to further enhance their rehabilitation planning.

Reports for Anglo Gold Ashanti

Reports for 2011 (GRI G3 guideline standards)

Anglo Gold Ashanti has made a commitment to mitigate climate risks and prevent pollution. The company is in the process of developing strategies for climate change, water security and reduction in energy consumption. Carbon pricing mechanisms by governments are important and relevant to the company. Anglo Gold Ashanti has provided the government with inputs in the development of climate change and GHG mitigation policy and has also implemented GHG reduction measures. Water supply and availability are important for the company. Where possible, Anglo Gold Ashanti try to maintain closed loop systems. The company is in the process of developing an integrated water management system throughout all South African operations due to the complex water dynamics in the area. Additionally, the company has identified physical climate risks as changing rainfall patterns, droughts, extreme weather events, high temperatures. Other risks that could affect the community are food security, water scarcity and health impacts. Anglo Gold Ashanti is in the process of developing site level action plans which include operational and engineering changes or capital improvements. The company also acknowledges that rehabilitation is an important component and the failure to adequately prepare may result in higher costs, missed opportunities and reputational damage.

Report for 2012 (GRI G3 Self-declaration Application Level A+)

The company has identified the following as material issues to the business: energy supply (and affordability), water supply and physical and regulatory effects of climate change. The company
continues to explore more energy efficient and less carbon intensive operational processes. Anglo Gold Ashanti states that adapting to climate change is one of the critical elements for the company. For water concerns, Anglo Gold Ashanti states that climate change will provide additional pressure to water resources when droughts occur, or alternatively a surplus due to flooding events; however, this is said to affect the operational phase more significantly. The company also highlights the importance of water during the rehabilitation phase of the mine lifecycle; however, the likely climate change impacts (e.g. floods, droughts) are not discussed as an additional concern.

**Report for 2013 (GRI G4 guideline standards)**

Similar to the 2012 reports, the company has listed competition for resources and infrastructure as material issues which could be caused by security to affordable energy, climate change. Anglo Gold Ashanti has developed a climate change strategy which addresses the reduction of GHG emissions to prepare for the introduction of the carbon tax. Physical and financial climate change related risks are identified to affect the business’ ability to continue and the communities’ ability to access energy, water and food. The targets that relate to climate change that the company provides are those related to reducing GHG emissions. In the year 2013, Anglo Gold Ashanti prepared a Biodiversity Management Standard which seeks to address biodiversity challenges that include population and economic growth as well as climate change. This standard is said to assist in providing the minimum performance requirements for operations and assist the company in its effort to enhance biodiversity through the different rehabilitation programmes.

**Reports for BHP Billiton**

**Report for 2011 (GRI G3 Self-declaration Application Level A+)**

Climate change is among the three environmental focus areas together with water use and biodiversity management. Recognizing that climate change could pose a business risk, the company makes climate change one of the focus areas in order to reduce their influence on climate change and also contribute positively. The company has accepted that anthropogenic causes of climate change and has taken a stance in acting on the findings while not affecting economic development negatively. Seeing the competitive advantage in reducing emissions now, the company believes changing energy
sources to low carbon ones at this moment would be effective. In mentioning the risks and opportunities of climate change, the company realises that it should change the design of some business assets to develop a greater resilience to climate change and thus build a business advantage. Overall, the company has clearly shared the physical climate change impacts that their business is susceptible and further shows how if such risks are addressed early, they potentially lead to an opportunity. However, having said this, no reference is made to climate change and rehabilitation. Although the company recognises that the introduction of the carbon tax is inevitable, they feel that such should be done in a transparent and sequential process so that the long term repercussions are not predominately negative.

_Report for 2012 (GRI G3 Self-declaration Application Level A+)_

The company is aiming to reduce its impact on climate change and thus climate change is one of the environmental focus areas, similarly to the SD15 of 2011. Knowing the climate change related risks will assist in the company contributing positively to the environment, society and the business environment. In building on to the SD15 or 2011m the company clearly states the principles being used to develop a climate change policy. Important to note that the company does mention climate change issues within some of projects running, these are presented as objectives.

_Reports for DeBeers_

_**Report for 2011 (GRI G3 Self-declaration Application Level A+)**_

In the year 2006, DeBeers developed an Energy and Climate Vision Strategy as part of their sustainable development framework. As part of the Environmental component of the sustainability objectives, DeBeers planned to mitigate and manage risks that the business and communities are susceptible to which are posed by climate change and water scarcity. According to a sustainability risk matrix developed by the company, water and energy security due to climate change are
considered long term high business risks. The company aims to minimise environmental impacts that may arise due to energy use and GHG emissions, including any climate change implications. The company also has six Environmental Standards which, among other issues, include climate change and pollution prevention. Biodiversity Action Plans are used to ensure that closure plans integrate good site level planning and climate change mitigation and adaptation. Physical climate change risks have been identified to be extreme weather events and increasing temperatures which together will affect water availability for the company. This in turn is said to present conflict between the business and the communities around. DeBeers also has a Climate Change Standard that guides the company in setting energy reduction targets. Furthermore, the company anticipates that physical climate change impacts will significantly affect the operations of the business and therefore acknowledges that adaptation measures need be taken. For future plans, the company aims to ensure that climate change risks are assessed and included within the Group’s risk pool. The company revised the environmental management plan (EMP) and rehabilitation liabilities during the rehabilitation activity undertaken at the Namaqualand Mines.

Report for 2012 (GRI G3 Self-declaration Application Level A+)
DeBeers is an active participant of knowledge sharing bodies such as the Worldwide Fund for Nature (WWF-South Africa) and the UNGC, which share local and international initiatives on responding to climate change. The company is also committed to tackling climate change in general. Similarly to the previous year, the company has six Environmental Standards which it uses to benchmark itself against other mining companies as well as international best practice. DeBeers continues to prioritise climate change adaptation and mitigation. In the year 2012, DeBeers assisted the WWF and the CSIR to in projecting physical climate change impacts during the 21st century. During 2012, the company also reviewed financial provision for closure as well as assures that all its operations will present effective rehabilitation. Rehabilitation planning is conducted during project development to ensure that maximum potential is attained. For different operations, different forms of rehabilitation are undertaken such as dump sloping, topsoil replacing, seedling and transplanting etc.
**Report for 2013 (GRI G4 guideline standards)**

Government and communities are the stakeholders with the most material interest in water and energy security due to climate change. The company states that it acknowledges the interconnections in the natural environment such as biodiversity and ecosystem services, climate change, water, waste and pollution. Additionally, DeBeers states that climate change can be effectively challenged with collaboration between industry, governments, NGOs as well as communities. Mining activities by DeBeers are said to have a negative impact on water sources as well as on global climate change. Should temperatures increase due to climate change, DeBeers expects to spend more money on cooling equipment and has already started implementing GHG emissions reduction initiatives. In 2013, DeBeers also developed a new five-year Environmental Goal where the company aims to be aligned to best environmental practices with the following focus areas: risks; resources; rehabilitation and biodiversity; requirements and reporting; and reputation. For rehabilitation, the company accounts for two different closure practices i.e. concurrent rehabilitation as well as post-production closure rehabilitation.

**Reports for DRD Gold**

**Report for 2011 (King III Report guidelines)**

Rehabilitation is placed among the key topics that are addressed by government, communities as well as non-profit organisations. Climate change is considered to only be of a moderate risk mainly due to the energy costs. Although the company has stated that it is aware of the potential climate impacts that will affect them, there has not been any further elaboration on efforts to assist in dealing with the impacts. On the other hand, extensive discussions around rehabilitation were presented especially those pertaining to acid mine drainage (AMD) leading to water contamination. Flooding has also been posed as one of the mechanisms that contribute to water contamination.

**Report for 2012 (GRI G3 Self-declaration Application Level C)**

Unlike in the previous year (SD 11 of 2011), there was no explicit mention of possible physical impacts of climate change to the business. The only component mentioned which was associated with climate change were the energy demands and the greenhouse gases that resulted.
Water contamination is also a great issue for the company where most of the contamination is as a result of the previous mining activities.

**Report for 2013 (GRI G3 Self-declaration Application Level B)**

Similarly to the SD11 of 2012, there was no direct mention of climate change issues besides those related to probable high energy costs in the future. However, the company does state that there is a significant problem with the water that has flooded the basins and some rehabilitation areas and thus rehabilitation is not able to proceed. It is unfortunate that this company has identified the current weather risks but has failed to state how it shall deal with such conditions in the future when climate change impacts such as increased rainfall occurs.

**Reports for Gold Fields**

**Report for 2011 (GRI G3 Self-declaration Application Level A+)**

The company appears to be seriously affected by AMD and has thus dedicated research and other programmes towards the treatment of water quality in the area they mine in. The company has additionally reviewed emergency plans should flooding occur especially in the context of AMD. The company does appear to be paying attention to the recent weather conditions and attributing these to climate change, more specifically the increased prevalence of floods and thus a Carbon Management Strategy has been devised to address increasing temperatures as well as frequent flood events. Rehabilitation in the form of vegetation is used for both dust control and soil erosion suppress.

**Report for 2012 (GRI G3 Self-declaration Application Level A+)**

In delivering the various issues that the business is succumb to, environmental challenges are highlighted to be major issues preventing business growth and these relate to water scarcity. There does not seem to be any explicit mention of climate change but it may be further implied around issues of water scarcity, energy constraints and the carbon tax. Within the report, one of the environmental challenges that the company faces is soil erosion together with stagnant water mostly in waste deposit areas.

**Report for 2013 (GRI G3 Self-declaration Application Level A+)**

Due to the nature of the mining activities that are perused by this company, there is major water contamination that results. Thus the company has developed many water treatment programmes
which are both short and long term. The company further states that it uses vegetation to ensure the contaminants do not leach into the soils and further into the groundwater system and thus the vegetation acts as both a system to halt soil erosion and prevent contamination. The company does not see the introduction of the carbon tax policy as a beneficial strategy since many of the energy efficiency strategies that need to be implemented are very costly.

Reports for Impala Platinum

*Report for 2011 (GRI G3 Self-declaration Application Level B+)*

Although climate change poses many risks to Impala Platinum, an opportunity of this is the development of a new market demand to eradicate fossil fuel based energy production by moving to fuel cells. Knowing the nature of business, the company presented that environmental and societal issues were pivotal in all their mining processes up until closure where rehabilitation takes place. The company further acknowledged that climate change will pose a threat to the overall continuity of the business. The report showed that Impala Platinum was thoroughly motivated to deal with issues that address water scarcity as well as energy constraints which were coupled with increased costs. To also deal with some water issues, Impala Platinum considered combining with research institutions as well as other mining houses to deal with the underground water system. The main rehabilitation strategy employed by Impala Platinum is phytoremediation where vegetation is used to remediate toxic land. The company further acknowledged that should TSFs not be rehabilitated quickly, they pose a threat of contaminating the underground water system.

*Report for 2012 (GRI G3 Self-declaration Application Level A+)*

The sustainable availability of water and energy were placed as one of the key components that would enhance the company’s sustainability strategy and ensure that business was profitable. The company was also aware that the two aforementioned resources are shared and thus they need to act very responsibly in ensuring that all stakeholders are satisfied. Thus, Impala Platinum set water conservation strategies together with carbon mitigation strategies. When the company referred to climate change response strategies, it was only concerning energy (especially in reducing GHG emissions) and to a small degree the water issues.
Report for 2013 (GRI G4 guideline standards)
Within Impala Platinum’s strategy to preserve natural resources, energy and water management, climate change control as well as land management were mentioned. Placed above all the aforementioned issues was the issue of water management in an area with low water availability. The company acknowledged that by managing the natural resources efficiently, the liabilities were greatly reduced. In Impala Platinum’s rehabilitation strategies, there was mainly the phytoremediation technique that was employed to stabilise and remediate the contaminated soils. This was said to be executed and monitored by university institutions.

Reports for Kumba Iron Ore

Report for 2011 (GRI G3 Self-declaration Application Level A+)
Firstly, in the opening statements of the company, the executive states that sustainability consists of a holistic approach to environmental governance not just focusing on a single segment. In its efforts to effectively deal with climate change, the company has endeavoured to conduct regional assessments so as to gather enough data to develop adaptation strategies. Additionally, climate change adaptation strategies are being incorporated into the overall business performance framework. In presenting the financial implications associated with climate change, the company does reiterate that there is much uncertainty within this field and thus financial provisions have not been accounted for. Additionally, it is stated that the impacts may result in great financial effects. However, as the climate change strategy is being carried out in the coming years, the company shall receive more enlightening information to assist with making the appropriate financial provision.

Report for 2012 (GRI G3 Self-declaration Application Level A+)
Even though the company has identified the regional changes in the area of operation there are still some changes and decisions that the company is making about climate change that are not necessarily considering the findings of the regional studies. The company has decided to raise the slope of the TSF to accommodate for more waste deposits while reducing the footprint; however, this may prove to be problematic in the future since the area is expecting increased rainfall.
Report for 2013 (GRI G4 guideline standards)
From the onset of exploration, the design is influenced by rehabilitation planning in such a way that it results to minimal natural land disturbance. Rehabilitation is also integrated into the overall business model of the company to further show the characteristics of a good corporate citizen. The company mentions water, dust and carbon footprint as the three most crucial environmental concerns that need to be addressed. In discussing the waste disposal, the report mentions that slope failure is one of the challenges of rehabilitation.

Reports for Company Lonmin

Report for 2011 (GRI G3 Self-declaration Application Level A+)
Having realised that climate change poses a significant risk to the running of the business; the company has integrated climate change into the business model. Climate change is placed as a separate problem to the other additional environmental management problems which encompass air, water, energy, waste, land and closure management. As an environmental strategy, the company ensures that water and energy consumption is at its minimal levels. The company has also been experiencing an increasing trend of water incidents in the years and thus water contamination is a vital problem. The company is every aware that the nature of their business results in great land degradation and possible contamination levels to the natural environment and thus the company takes a pro-active response to rehabilitation management to minimize waste production. In developing its climate change response strategy, the company focuses on four items which are adaptation, governance, resource management as well as capacity building. The company has also gone through many efforts to identify both risks and opportunities that affect the company in a top-down and bottom-up manner. The company also then presents the likely regulatory and physical risks that the business is prone to, and in the presentation the company does state that evapotranspiration may affect suppression on TSFs. The risks identified are dealt with by a multidisciplinary team. The company has already seen water contamination occur as a result of extraordinarily high rainfalls and thus borehole monitoring systems have been put in place to deal with the problem.
**Report for 2012 (GRI G3 Self-declaration Application Level A+)**

The company appears to be very dedicated to rehabilitation as it pursues monitoring and evaluation processes after formal rehabilitation has ended and also taking a precautionary approach during the entire mine lifecycle. For this monitoring and evaluation process, the company is assessing water quality, water quantity as well as vegetation establishment. The report clearly shows the governance dynamics within the company in terms of which different committees report to which executive personnel and thus this promotes responsibility and transparency. Similarly to the previous reports the company acknowledged that their reliance on fossil fuel based electrification will prove to be an issue in future firstly with the costs associated with it and the further GHG emissions taxes. The company has a good history and account of past weather patterns and shows some knowledge of come changed patterns which pose a threat should they continue in the future; these mainly pertain to water availability. Climate change has been further integrated into the business where funding has been provided for renewable energy research and water management research. The company has also had a past incidence where due to structural fail (from vandalism), contamination via dust (dry conditions) and seepage (lower liquid phases) occurred contaminating the soil and groundwater.

**Report for 2013 (GRI G3 Self-declaration Application Level A+)**

As a result of the concerns in energy and water that have been raised, climate change matters are raised throughout the report as this appears to be the common cause of the issues raised. The company appears to be considering itself in relation to other activities in the area where it realises that there is pressure on natural resources and it thus needs to act responsibly and with the community. There also is a continuing awareness of climate change impacts such as droughts and floods which may affect the business. The company has identified drought to be a characteristic of a climate change impacts in the area that the company is based. Climate change policy drafted in line with the risk management policy of the company. The company presents findings and statements in a way that shows that research has been conducted and showing great measures of accountability.
Reports for Northam Platinum

**Report for 2011 (GRI G3 Self-declaration Application Level B+)**
The company has identified a great opportunity in the commodity it mines with the implementation of climate change policies. The company describes climate change risks as being moderate. However, Northam Platinum did mention that large amounts of water loss were being experienced in the closed circuit system due to evaporation especially during summer where temperatures were high and thus more water potable was used in the process. The company further acknowledged that water may become an increasingly limited resource with climate change. There was no explicit mention of which climate change risks which are classified to be physical risks; however, there was knowledge of the most harmful and highly concentrated GHG. Interestingly, this company stated that full rehabilitation of some mines will only commence once the mine had been closed.

**Report for 2012 (GRI G3 Self-declaration Application Level B+)**
The company acknowledged that the nature of their business affected land, water, ecosystem functioning and general natural resources and further defined water, land and energy as the most significant challenges. Much emphasis was placed on water management in terms of monitoring the quality and quantity for both surface water and underground water. Similar to the previous report, the company presented that evaporation proved to be at high levels during summer and thus much water was lost consequently which resulted in the use of potable water as a supplement. Furthermore the company understood that water may also prove to be a constraint in future due to climate change and thus good management now will be beneficial for the future and in maintaining good community relationships, since water was a shared resource.

**Report for 2013 (GRI G3 Self-declaration Application Level B+)**
In all three reports the company did not mention likely physical impacts of climate change such as floods, storms, droughts etc. The company identified some opportunities in the market they were already in with climate change policies being implemented. Over and above everything, the company recognised that the nature of their business resulted in the harm of natural resources especially water, land and energy and thus these elements were highly prioritised. According to the
report, the company considered the holistic nature of climate change which incorporates financial implications as well. Although the Northam Platinum had started concurrent rehabilitation in some areas, this was mainly for dust suppressions and they further state that rehabilitation will commence after closure.

Reports for Royal Bafokeng Platinum

**Report for 2011 (GRI G3 Self-declaration Application Level B+)**
The company appreciates that resources such as water and energy are vital for business and are confident that the available resources are sufficient for their short to medium term requirements. Climate change and other related subjects are placed on the agenda for meetings with the non-executive members. Climate change is presented to be the areas affecting the natural capital department of the business. In the challenges that the company has had for the year, climate change, resource management (water and energy) together with waste management and legal compliance are among them. The company has identified that climate change could pose physical threats to the business operations as well as to the surrounding communities. Financial provision for rehabilitation is an estimate depending and based on available technological techniques and thus is likely to increase and be more accurate close to closure.

**Report for 2012 (GRI G3 Self-declaration Application Level B+)**
The company is active in the reporting sphere having been recognised by reporting organisation. The company is experiencing excessive water on their tailings and has thus developed a strategy to deal with the excess water temporarily. Climate change and waste management are placed as the challenges facing the company in the environmental department. Decisions on environmental issues such as climate change are made by the Board of Directors. Rehabilitation and land management programmes are highly considered by the company as these ultimately reduces risk within their company.

**Report for 2013 (GRI G3 Self-declaration Application Level B+)**
The company shows that through natural resource inputs it is able to produce its commodity and is then encouraged to rehabilitate the land it was working on. As a result of the business operations, air quality depreciate, soil and water contamination occurs and biodiversity is potentially
lost but the company has acknowledged these and has developed strategies in response. As part of their manufactured capital, tailings dams and storm water dams are constructed and are later rehabilitated at the end of the operational phase. Rehabilitation is implemented as soon as operations commence until post closure where monitoring on the site is carried out. Having conducted a detailed risk vulnerability assessment, the company has identified that it is susceptible to flooding and extreme storm conditions in the area it is operating in and thus water will prove to be a limited resource. Interestingly, although the company has identified floods and extreme storms as the most significant risks identified, there is still a risk of droughts as the operations are in an arid region and also as a result of the poor quality of water that may be in excess during floods and storms. In relation to closure and rehabilitation, the company is still using the 100-year flood measurement for TSF designs. But the company does go on to say that there are measures in place to determine whether the capacities of the TSFs are still within regulated limits. Closure plans with rehabilitation plans have been put in place but these are temporary ones as these will be finalised five years prior to closure.

Reports for Sasol

*Report for 2011 (GRI G3 Self-declaration Application Level A+)*

The company participates actively in climate change dialogues both locally and internationally. In addition to welcoming the scientific findings on climate change, the company appreciates the new developments have to proceed in a manner that is hospitable to business growth while also harnessing society’s needs. The company also acknowledges that by developing in a manner that mitigates climate change risks, it would gain a competitive advantage. The company not only sees climate change bringing risks but also opportunities in technological innovations. The company has also to develop a climate change strategy together with the safety health and environment committees. Majority of climate change responses are in relation to reducing the companies GHG emission levels the only different targets being to involve stakeholders in the climate change debate as well as engage employees. Although not explicitly mentioned, the company does highlight that good rainfall in the past has masked the risks of receiving lower rainfall than predicted which would be problematic as the water resources are a shared one.
Climate change together with air quality and safety are placed as the greatest challenges that the business is experiencing. Similarly to the previous report, climate change is only discussed in relation to energy issues as well as some water challenges to some degree. The company is also seeking for solutions that will still assist the business to grow well while also responding effectively to climate change. The company has also designed a risk programme that caters for all departments in the business. The climate change strategy that the company has developed is in line with the company’s overall core strategy. Although the report does not mention what climate change impacts will affect them, a study done on their operations has shown that their operations are susceptible to weather related events which resulted in many financial implications in the past. Thus the company aims to identify all climate change risks by collecting data effectively and thus be equipped with adaptation strategies.

The company has made great shifts in business running where no further investments are made in coal based fuels for energy production. The company also acknowledges that a commitment to sustainable development further assists in mitigating risks and thus managing the business profitably with a good reputation. There are five key focus areas for the company where one is responding to environmental challenges. In addition to taking action against climate change, the company believes that government should develop strategies that will not significantly affect the economy. Following from the extreme weather events assessment conducted as reported in the 2012 document, the company is undergoing a rigorous process of identifying such challenges in future to adapt and prevent financial losses.

Treatment of water quality has become very important for the company due to incidences of AMD. The company does appear to be paying attention to the recent weather conditions and attributing these to climate change, more specifically the increased prevalence of floods and thus a Carbon Management Strategy has been devised to address increasing temperatures as well as frequent
flood events. Rehabilitation in the form of vegetation is used for both dust control and soil erosion suppress.

**Report for 2012 (King III Report guidelines)**
In delivering the various issues that the business is succumb to, environmental challenges are highlighted to be major issues preventing business growth and these relate to water scarcity. There does not seem to be any explicit mention of climate change but it may be further implied around issues of water scarcity, energy constraints and the carbon tax. Within the report, one of the environmental challenges that the company faces is soil erosion together with stagnant water mostly in waste deposit areas.

**Report for 2013 (GRI G4 guideline standards)**
Within the natural capital, the company consumes mostly water and energy. Closure plans that also incorporate rehabilitation programmes are developed at the beginning of operations and thereafter are updated. Additionally, the closure plans consider the surrounding communities. The company also appreciates that the natural capital requires ecosystem processes to function optimally and included in these are the carbon cycle together with climate regulation. Thus the company acknowledges that it has a negative impact on these natural capital constituents and consequently has strategies in place to address such impacts. In efforts to restore land appropriately, the company is undergoing an assessment to determine whether the land that has been mined can be used for agricultural purposes. The company has not revealed any physical impacts that may arise due to climate change.
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