UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

DEPARTMENT OF CHEMICAL ENGINEERING

Sustainability Assessment of Post-Mining Land Use Planning

By

Prince Destiny Ugo

Supervisor: Professor Harro von Blottnitz

A dissertation submitted in partial fulfilment of the requirements for the degree of Master of Philosophy specialising in Sustainable Mineral Resource Development in the Department of Chemical Engineering.

November 2019

PLAGIARISM DECLARATION

1. I know that plagiarism is wrong. Plagiarism is to use another's work and to pretend that it is one's own.
2. I have used the Harvard Convention for citation and referencing. Each significant contribution to and quotation in this dissertation from the work or works of other people has been attributed and has been cited and referenced.
3. This dissertation is my own work.
4. I have not allowed and will not allow anyone to copy my work with the intention of passing it off as his or her own work.
5. This dissertation has been submitted to the Turnitin module and I confirm that my supervisors have seen my report, and any concerns raised have been resolved with the supervisor.

Student Number	Name	Signature
UGXDES001	Prince Destiny Ugo	Signed by candidate

DEDICATION

I dedicate this work to:

My father, HRH Uche Ugo, the Eze-Obiligwe 1 of Ogba Kingdom.

ABSTRACT

Mining, by its nature, provides enormous investment to the mining nations and by extension contributes to the socio-economic development of the host communities. Where these communities exist, they remain a cause of concern since they are predominantly dependent on the economic opportunities generated by the mine. The Environmental Impact Assessment (EIA) functions in mining are somewhat of a risk reduction activity, even though the potential of halting projects is comparatively rare in situations where proposals are deemed to be of national interest and politically significant. This study highlights the environmental and socio-economic impact of lack of land use planning in host communities where the phenomenon of mine closure is a lived reality and evaluates alternative post-mining land use.

In this study a case study, qualitative research approach is used to comparatively evaluate three mining EIA reports (EIA on the extension of mining operations at the Vlakvarkfontein Coal Mine; consolidation of high extraction mining impacts in the Trichardtsfontein; and rail loop, road diversion and pipeline project associated with Temo Coal) on the extent of post-mine land use consideration in the EIA process. Furthermore, the study, inter alia, assessed the extent to which the interested and affected parties' input was considered in EIA reports. In rehabilitation, the applicant is only reinstating the area, as closely as possible, to that which existed pre-mining, and should not be confused as post-mining land use. There is nothing new in providing for rehabilitation in EIA – it is a standard practice.

However, the mining EIA reports extensively covered the environmental components, particularly the specialist studies, as they assessed whether projects conformed with the regulatory requirements. The emphasis of the mining EIA reports was mainly on the environmental component with – other than employment and economic benefits – no post-mining land use and socio-economic impact indicators. These trends were found to be further reinforced when the input of the interested and affected parties (I&APs) was analysed.

In view of the findings of this study, the main recommendations to improve the EIA systems would be to clarify and simplify the mandates of the several institutions involved in the EIA process and system; and to improve and increase public access to EIA reports, including electronic means.

This is pertinent due to the conspicuous absence of EIA reports in the public domain, which contributed to the limited number of EIA reports that were reviewed in this dissertation. In addition, public participation processes (PPP) should be conducted in most common languages of the stakeholders; and specialist social impact assessment should go beyond the traditional socio-economic issues faced by I&APs to include post-mining land use, as well as sustainable post-mining economy.

ACKNOWLEDGEMENT

I would like to thank my supervisor Professor Harro von Blottnitz, who is also the Director of the Environmental & Process Systems Engineering Research Group in the Department of Chemical Engineering, for his invaluable time, encouragement, and support throughout my studies. Without you I would not have completed my studies at the University of Cape Town, I am glad that you committed yourself to making this happen for me. Professor Harro, you are an embodiment of the *Ubuntu* philosophy.

I would also like to thank Professor Jennifer Broadhurst, the convenor of the MPhil programme, for introducing me to Resilient Future community of practice (CoP), which provided direction towards the formulation of this dissertation. The financial support from the CoP project is appreciated.

Thank you to the management and staff of Digby Wells Environmental, for the opportunity to complete my internship at Digby Wells. To Professor Besa, Dean of the University of Zambia (UNZA) School of Mines, and his team at UNZA; thank you all for hosting me and my colleagues as part of this programme.

Thank you to Dr Shahieda Jansen for providing me with every support necessary to finding my niche in life. I am very grateful to my family for believing in me, I miss each of you, but it is well!

I am thankful to the African Development Bank (ADB) for the financial support towards my studies as part of United Nations Education for Sustainable Development in Africa, (UN-ESDA), and I thank the Minerals to Metals (MtM) Initiative for the technical support.

The financial assistance of the National Research Foundation (NRF) towards this research is hereby acknowledged. Opinions expressed, and conclusions arrived at, are those of the author and are not necessarily to be attributed to the NRF.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

AAMCT	Anglo American Mine Closure Toolbox
AANDC	Aboriginal Affairs and Northern Development Canada
ADB	African Development Bank
AHP	Analytical Hierarchy Process
AMV	African Mining Vision
ASM	Artisanal and Small-scale Mining
AU	African Union
AUC	African Union Commission
CA	Competent Authority
CBA	Critical Biodiversity Area
DAFF	Department of Agriculture, Forestry and Fisheries
DEA	Department of Environmental Affairs
DEAT	Department of Environmental Affairs and Tourism
DM	Decision Makers
DMR	Department of Mineral Resources
DWA	Digby Wells and Associate
EAP	Environmental Assessment Practitioner
ECA	Environmental Conservation Act
EEZ	Ecological and Economic Zoning
EGS	Ecological Goods and Services
EIA	Environmental Impact Assessment
EIMS	Environmental Impact Management Service
EMP	Environmental Management Plan
EMS	Environmental Management System
ESA	Ecological Support Area
FDI	Foreign Direct Investment
GIS	Geographic Information System
I&APs	Interested and Affected Parties

ICMM	International Council on Mining and Metals
IEMS	Integrated Environmental Management System
LCC	Land Capability Class
LoM	Life of Mine
LSA	Land Sustainability Analysis
LUP	Land Use Plan
MADM	Multi Attribute Decision Making
MLSA	Mine Land Suitability Analysis
MPRDA	Mineral and Petroleum Resources Development Act
MVLWB	Mackenzie Valley Land and Water Board
NDP	National Development Plan
NEMA	National Environmental Management Act
SDGs	Sustainable Development Goals
SIA	Social Impact Assessment
TCM	Temo Coal Mine
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution
UNECA	United Nations Economic Commission for Africa

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND TO RESEARCH

Mining, by its nature, offers substantial income to mining countries and, by extension, adds to the socio-economic growth of host communities (Stacey, Naude, Hermanus, & Frankel, 2010; Azapagic, 2004). However, there is sometimes a conflict of interest between various public interests, and environmental legislation. This is most pronounced between the willingness to attract mining capital and the need to comply with environmental requirements, which is further complicated when the government is a shareholder in the venture (Van Zyl et al. 2002). What appears to be most crucial, is a national strategic agenda that promotes the execution of an environmental impact assessment (EIA) system that respects the bureaucratic and methodological capabilities and infrastructure needed to manage the environmental impact (Petts, 1999a). Mining operations involve changes to the surrounding area and land use, the magnitude would depend on several variables, which include mining and processing techniques, the type of ore, and the location of the deposit (Heikkinen et al. 2008).

Morgan (2012) identifies that many countries have incorporated some form of impact assessment process into formal procedures or legislation relating to planning or to other areas of environmental decision-making. For instance, in Peru, companies are obligated to obtain approval from the competent authorities of their environmental impact assessment (EIA), and such assessment must detail a community participation program and execution before they can start a project which represents environmental impact (Pósleman & Sallan, 2019). This process of community inclusivity is an important reason for mining companies to obtain social support to carry out extractive activities, the need to attain a social license to operate continues to be a front burner in the discourse of both extractive industries and in natural resources management (Mercer-Mapstone, et al. 2017). Similarly, Harvey & Bice (2014) argued that a successful approach to obtaining social license to operate requires working directly with affected stakeholders, hence companies must define what constitutes a community and who its relevant stakeholders are, in order to develop procedures and systems to prioritise stakeholder’s expectations and requirements.

Frank & Cohen, (2012) refers to Social License to Operate (SLO) as the intangible and unwritten, tacit, social contract with society, or a social group, which enables an extraction or processing operation to enter a community, start, and continue operations. However, Owen & Kemp (2013) argues the extent to which social licence reflects a bias towards aggregate or local social issues has yet to be established. A more localised interpretation of social licence by industry would appear to engage the subsidiarity principle, which lies at the heart of sustainable development (Owen & Kemp, 2013). Mining adds considerably to the sustainability of South Africa's national economy but there is reliance on mineral assets and insufficient development of alternative economic ventures in mining towns (Odell, et al. 2011; World Bank, 2002). Over the next 25 years, many mines in South Africa will be closed (Prinsloo & Marais, 2014), resulting in more than 131 591 job losses (Chamber of Mines SA, 2015). Annual wages of R24 billion, and monies invested in the domestic economy, will be lost as well (Ndaba, 2010; Chamber of Mines SA, 2015).

This demonstrates that not only are mining activities adversely affecting the ecosystem, but the closure of mines also causes an adverse spill-over effect, such as populations that are left to struggle with the resulting unemployment, poverty, and poor living circumstances (Stacey et al. 2010). Moreover, the ability of indigenous communities and the central government to deal with development techniques that provide alternative economic prospects is sometimes very minimal (World Bank, 2002). There has recently been serious concern that the closure of some Lonmin mines in South Africa could result in more than 12 000 job losses over the next three years (Lechela, 2018; Steyn, 2018). Therefore, there is a need for sustainable post-mining land use. It serves to highlight both the socio-economic and environmental impact that mining has on host communities where the trend of mine-closure is lived experience, and measures put in place to mitigate negative impact. Furthermore, the study assessed the knowledge gained on mine closures, sustainable development, and the response of the mining sector to post-mining land use in the context of South Africa.

In this study, I conducted post-mining land use sustainability assessment through comparative analysis of mining environmental impact assessment (EIA) reports in South Africa. In the study, I utilised the qualitative research approach to evaluate three mining EIA reports on the extension of mining operations at the Vlakvarkfontein Coal Mine; EIA on consolidation of high-extraction mining impact in the Trichardtsfontein; and EIA on rail loop, road diversion, and pipeline project associated with Temo Coal) on the extent of post-mining land use consideration in the EIA process, as well as the context to, inter alia, how the socio-economic impact of mine closures on host communities was evaluated.

1.1.1. MINING AND COMMUNITY EXPECTATIONS

The socio-economic opportunities presented by mining ventures contribute to the sporadic establishment of fringe settlements around the mine sites (Sanchez, Mejia, & Bueno, 2009; Kretschmann, 2018) and, where these communities exist, remain a cause for concern as they are largely dependent on the economic opportunities derived from the mines (Limpitlaw, 2004; Noi & Ciroth, 2018). According to Van Heerden (2016), mining companies in South Africa employ many people who are not local residents but come from other parts of the country as well as other countries. When a mine closes, some of these miners do not return to their place of origin but remain in the mining area. The effect of this is that the burden on the local municipality increases while the revenues from the mine have been lost (Van Heerden, 2016).

For communities, the closure of mines, among many other factors, leads to serious distress as the socio-economic foundations of community existence are threatened (World Bank, 2002; Van Zyl et al. 2002; Mancini & Sala, 2018). This trend is sometimes severe in emerging countries, and the government often lacks the capacity and resources to formulate an alternative development and economic pathway (World Bank, 2002). As a result, the medium-to long-term socio-economic effects that host communities will experience as a consequence of mine closures, are often overlooked (Kretschmann, 2018). Even in countries where there are legal requirements for mine closure planning, host communities continue to be cautious about the intentions of mining companies (Ackerman, et al. 2017).

As a result, communities are often opposed to mining developments and continue to advocate for discontinuation in different parts of the globe (Stacey, et al. 2010; Mitchell, et al. 2008). There are many ways in which mines can provide the local population with possibilities for socio-economic opportunities (Limpitlaw, 2004). These socio-economic advantages of mining include the creation of work opportunities in the area, the development of infrastructure, and the provision for essential needs, such as drinking water and electricity, and the construction of schools and healthcare centres (Noi & Ciroth, 2018; Wessman & Salmi, 2014). Several mines do contribute to host communities by offering road construction, housing and other social amenities (Cooke & Limpitlaw, 2003). However, in instances where such corporate social responsibility and development projects add to the socio-economic welfare of the communities outside the core business of a mine, it is sometimes assumed to be mainly a measure for enabling mining production (Limpitlaw, 2004; Choshi, 2001).

1.2 ENVIRONMENTAL IMPACT ASSESSMENT

Despite improvements in the values of sustainable development, there exists an antagonistic connection between economic development and environmental protection, as decision makers nevertheless experience substantial difficulties in balancing natural mechanisms and human desires, between protecting the rights of people and those of community, and between providing essential services that improve quality of life and those of environmental management (Petts, 1999a; Glasson et al. 2006). The obstructionist function of the EIA to sustainability framework is well-known and documented, the former South African President Mbeki describing it as quite frightening (SBP, 2005; Swanepoel, 2008; Aucamp, 2009). This indicates that EIA appears not to advance the notion of sustainability, it is somewhat of a bottleneck.

A capability audit undertaken by the Environmental Affairs and Tourism Department (DEAT) highlighted the severe capability challenges faced by EIA managers (DEAT, 2008a; DEAT, 2008b). The study by DEAT demonstrates that optimal administrative capacity is required to cope with current work-load at the department (DEAT, 2008b). Although data may be present at organisational level, it is not readily released. In fact, legislative demands sometimes create barriers, with mining industries being constantly obliged to file countless records that could be handled simultaneously by a single entity. This replication gives rise to an enormous – some authors (Modak, Asit, & Biswas, 1999; Donnelly et al. 1998) describe it as "voluminous" – waste of resources.

The 1969 introduction of the environmental impact assessment (EIA), with regards regulations of United States National Environmental Policy Act, mandated that there should be consideration of environmental impact of national projects in the United States, prior to the execution of such projects (Wood, 2003; Glasson et al. 2006). This has helped to examine the technical and environmental alternatives of development projects and consequently to mitigate their prospective adverse effects. It has expanded across the world and evolved into a wide range of formats in various countries.

According to DEAT, (2004), in early 1970s concern at the time was about bio-physical components of the environment. To address complexities the environment was divided into sections (Weaver et al. 1999), which included looking at how certain activities impacted on environment specific sector such as the soil, water and air. At that stage, there was very limited stakeholder engagement, and public participation process were yet to be formalised, and this led to several litigations (DEAT 2004). However, during those first decades, the EIA culture established itself and some tools on how to conduct EIA were developed (DEAT 2004). The assimilation of practice and the idea of EIA into a variety of political and cultural settings indicates the desire and need to integrate environmental concerns into the processes of decision-making (Petts, 1999a).

This assimilation has, however, been limited in application, scope, and practice – particularly within the context of developing countries (Petts, 1999b; Petts, 1999c; Glasson & Salvador, 2000). This raises questions as to whether the inherited western EIA reporting format can or should be adapted into procedures for developing countries at national level, or whether this results in an approach which, in most instances, is often mechanistic, bureaucratic, voluminous, and continues to be done globally wherever there are new projects (Modak, Asit, & Biswas, 1999; Donnelly et al. 1998).

Considering the time frame within which these observations were made about *inter alia* bureaucratic and voluminous EIA processes, one would have expected that a regime change would have effectively addressed these challenges. Nonetheless, currently, changes to improve the status quo is insignificant, as is evidenced by this study.

1.3 SOUTH AFRICA EIA REGIMES

South Africa has more than three decades of mandatory environmental impact assessment (EIA) practice under three different EIA regimes (Polygon Environmental Planning, 2012). The initial regime was regulated by the Environmental Conservation (ECA), Act 73 of 1989 (South Africa 1989) referred to as ECA regime, and the second was regulated by the National Environmental Management (NEMA), Act 107 of 1998 (South Africa 1998), also known as the NEMA regime.

According to DEAT internal evaluation, the lack of success of the screening process was one major issue of the ECA system (Claassen et al. 2003, DEAT 2006, Van Schalkwyk 2006). The prevailing view regarding that era was that too many unnecessary EIAs had been triggered, placing enormous stress on the government's organisational capacity, including high-cost delays for development firms (DEAT, 2008b). The advent of a comprehensive screening framework to minimise the number of EIA applications was the focus of NEMA regime that necessitated the substitution of the ECA (DEAT, 2008b). The third regime, which came into action in August of 2010, was also regulated by NEMA, through enactment of the amended provisions (South Africa, 2010).

Various aspects and revisions to the EIA regulations and the listing notices have been published over the years – first in 1997 and then in 2006, 2010, and 2014 (Strydom, 2017), and further amendments have also been made to the specific activities listed during this cycle (Strydom, 2017). The environmental impact assessment (EIA) regulations established various mechanism to follow when applying for an environmental licence, on the other hand listing notices specify the activities that need authorisation. Strydom (2017) further notes that the latest changes to the environmental authorisation regime were released by Environmental Affairs Minister on 7 of April 2017.

These amendments seem to lend more weight to the implementation of what became known as the “one environment system” (OES), which is an accord between Ministries of Mineral Resources, and those of the Environmental Affairs, Water and Sanitation, for the integrated environmental management system for mining. The changes made in 2017, through the temporary clauses, seek to explain the stance after 8 December 2014, regarding the environmental authorisations and environmental management programmes (EMPs) for mining (Strydom, 2017). Different processes and procedures are used by various nations to conduct the EIA (Borzel & Gupta 2000). As one of the accepted instruments for achieving sustainability objectives, the quality of the EIA framework and the product of the EIA system must be assessed from a sustainability point of view (Wood, 2003).

In South Africa, the EIA documents include specific elements, as shown in Figure 1, such as scoping, screening, public involvement, options considerations and mitigation evaluation, authorisation, as well as post decision tracking (Wood 2003; Glasson et al. 2006). Environmental Impact Assessments must be performed by environmental assessment practitioners (EAPs) and such assessment needed to establish whether the exercise requires a basic evaluation or complete assessment. The environmental assessment practitioners (EAPs) must perform public participation procedure for all activities, including compiling a list of interested and affected parties (I&APs), and the draft report must be published for 30 days for public notification.

An application is submitted for environmental authorisation, a fundamental assessment or a complete evaluation document, and information of the public participation process to the relevant authority, which must decide whether to grant an environmental authorisation, grant it depending on different requirements, or reject submission. Decision is taken within the specified timelines set-out as per the regulations (Figure 2). The timeline for submission of applications is 44 days from the date of release of the final assessment study to the Department of Mineral Resources (DMR) and this includes 30 days for remarks. The environmental assessment practitioner (EAP) has 106 days to submit final EIA report. The DMR, has 107 days to approve or dismiss final EIA report and, once the choice has been made, it may be revised, revoked, and appealed.

Lehman, et al. (1998) observed that the EIA processes are intended to provide a knowledgeable assessment of the potential environmental impact of projects and to add to the mitigation of the adverse effects of the project. Van Zyl et al. (2002) contend that when it comes to carrying out an EIA, socio-economic factors are typically included as a distinct segment of the study, and sometimes not until a big part of the original planning has been completed. This also applies to the disposal technique and positioning of waste storage installations. Changes in land use associated with mining are long lasting with adverse effects (Chen et al. 2015) and are anticipated to expand along with the mining areas (Limpitlaw & Woldai, 2000; Cooke & Johnson, 2002; Kangwa, 2008).

This is further compounded by the reality that South Africa has over five thousand derelict mines without owners (DME, 2007). As these mines return to the state when they are decommissioned, it is projected that the state's economic liability is at least R30billion for rehabilitation of the environment alone (Baartjes & Gounden, 2012). The figures exclude mines that do not operate but are under diverse levels of care and maintenance, implying that, such mines have not reached definitive legal closure.

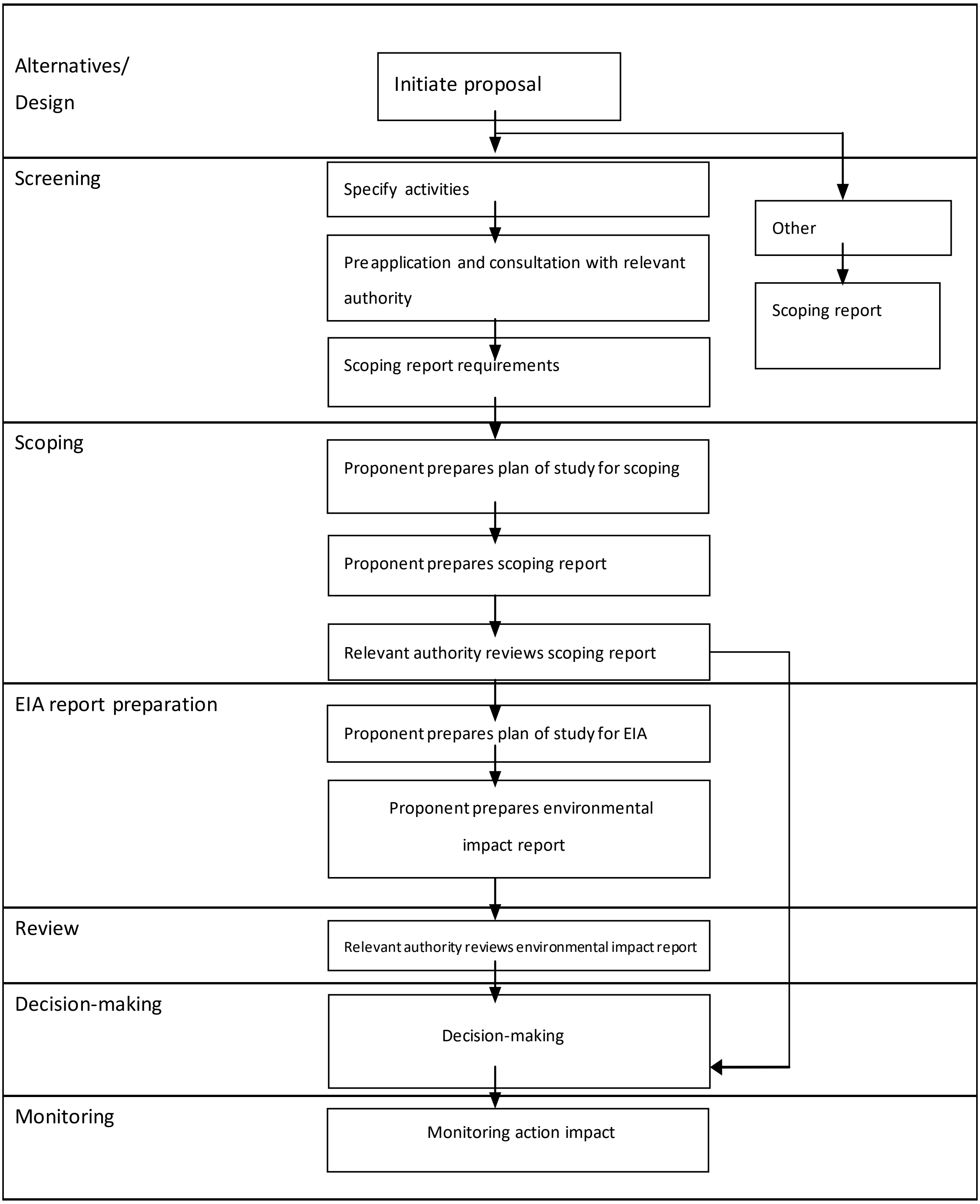


Figure 1: EIA Process. Source: Wood, (2003).

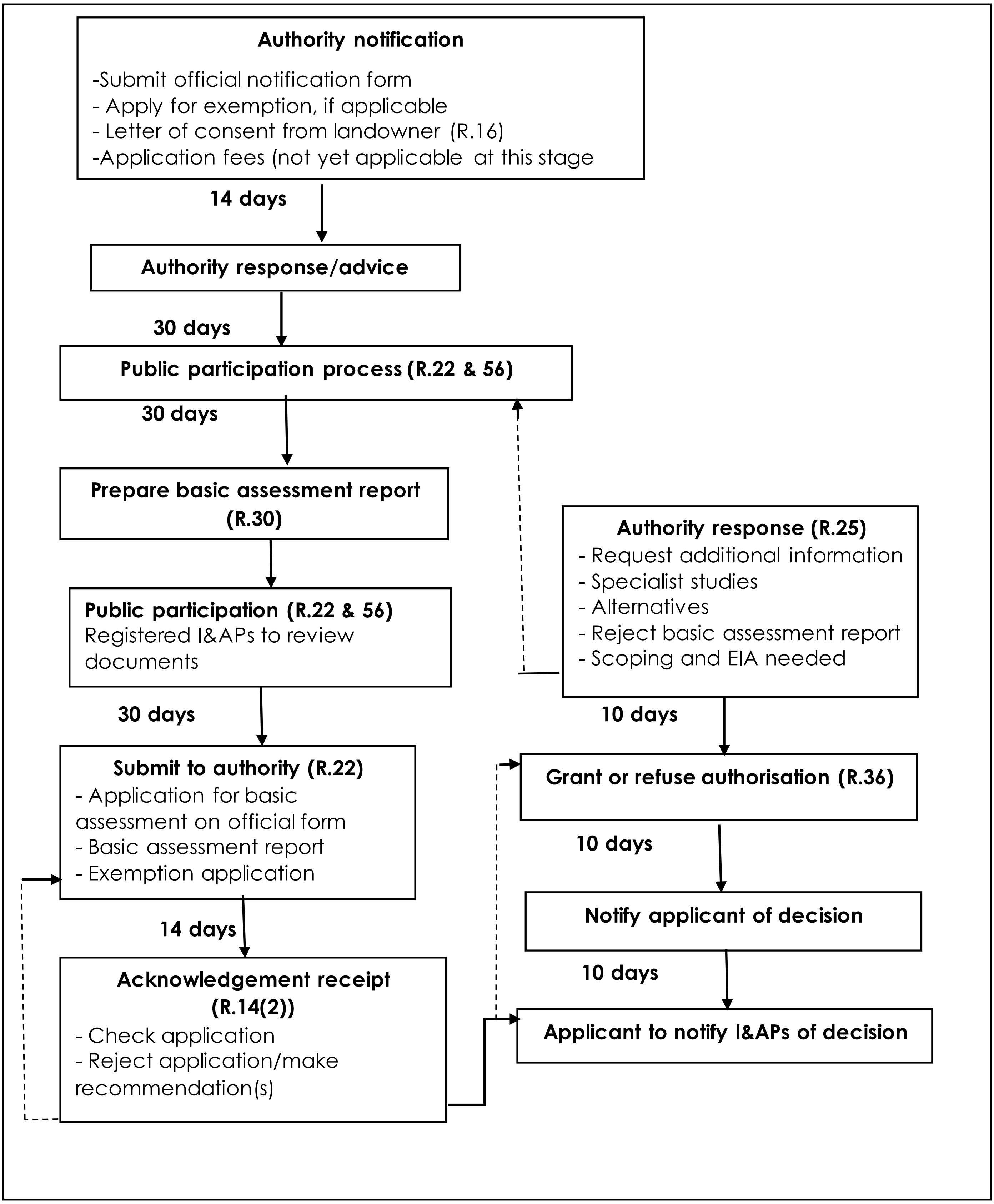


Figure 2: Assessment Process. Adapted from DEA&DP workshop (2006).

The most significant effect of mining is the land use change, induced by clearing of vegetation, topsoil extraction, and disposal of large volume of waste. Mine waste generally includes waste rocks, overburden, slag, and land surface tailings, while mine wasteland consists of reclaimed fields, loose soil stacks, overloaded slopes and waste rocks, subsided land, tailings dams, open pits, and other land degraded by mining (Wong, 2003; Li, 2006; Sikaundi, 2013; Venkateswarlu et al. 2016).

1.4 PROBLEM STATEMENT

The real benefit of the environmental impact assessment to the sustainable post-mining land use planning has been a major concern, particularly within the context of developing countries. The subsequent burden on state and business capacity, as well as resources, is traditionally criticised for environmental impact assessment studies, which are often centred on environmental impact mitigation but abstract to post-mining land use planning and socio-economic realities of impacted communities, characterised by inefficient and prolonged decision-making processes, along with high cost.

Thus, South Africa, among others, places strong emphasis on constant improvement and change of EIA regimes through amendment of legislation that has spanned more than three decades and has been specifically targeted at improving the EIA processes and organisational efficiencies. Most recently, the focus has been on the "one environment system", but the effectiveness of this new EIA regime with regard to post-mining land use planning also remains undetermined, as it was only an agreement between two government departments (i.e., Mineral Resources, Water Affairs and Sanitation) to have an Integrated Environmental Management (IEM) plan for mining.

1.5 RESEARCH OBJECTIVES

The objective of this study is to conduct a sustainability assessment of post-mining land use through comparative analysis of mining EIA reports. The study aims to analyse and present the contributions of environmental impact assessment practitioners (EAPs) as well as interested and affected parties (I&APs), in their attempt to co-create a sustainable future in mining communities, post-mine land use. In this study I explore the factors that positively or adversely affect EIA processes and regulations aimed at sustainable post-mining land use planning.

Thus, within the ambits of this dissertation, the specific objectives are:

- to conduct a regulatory framework review of mining EIA reports as instrument for planning and decision-making within the South African mining context. The purposes of the regulatory framework review is to highlight the various processes of EIA reports, what changes have been made in the various regimes, whether regulatory reforms and amendments contributed to sustainable post-mining land use, and if so, in what way.
- to conduct a detailed review of mining EIA reports in South Africa. This is done to provide an understanding of whether, inter alia, I&APs participation and input were considered in the EIA reports, and whether the stakeholders referred to post-mining land use in the public participation other than in terms of the immediate obvious benefits such as employment opportunities, and environmental impact mitigations.

1.6 RESEARCH QUESTION

The research question within the scope of this dissertation is as follows:

- Has environmental impact assessment (EIA) contributed effectively to the sustainability of post-mining land use planning in South Africa?

The research question is necessitated and supported by literature, inter alia, that South Africa is a mineral-rich nation with a long-established and economically important mining industry, and may thus be one of the more suitable locations to test whether sustainable mine closure, land use planning, and thus sustainable development, can be attained in the mining context (Global Mining, 2002; DEA, 2010a, CoM, 2011; Stats SA, 2012).

Closed mines also tend to obviate useful future land use to the detriment of ecosystem functioning, human health, and sustainable development (Robertson & Shaw 2006). Mine closure is often poorly planned for, which could exacerbate the environmental and socio-economic impact. Thus, considering the objectives of this study and the role of EIA reports as a vital instrument that serves to mitigate these challenges, I ask whether *environmental impact assessment (EIA) contributed to post-mining land use planning in South Africa?*

1.7 STUDY SCOPE AND LIMITATION

The scope of this study is to conduct a sustainability assessment of post-mining land use by reviewing mining EIA reports.

The study limitation is that:

- It focuses mainly on mining end land use planning, and
- There is noticeable lack of South African mining EIA reports in the public domain, which is unusual as EIA reports are presumed to be public documents. However, this affected the number of EIA reports that were reviewed in the study.

1.8 SUMMARY

As illustrated by the Mineral and Petroleum Resources Development Act (MPRDA) (DME, 2002) and; the National Environmental Management Act (NEMA) (DEAT, 1998), South Africa is dedicated to handling the closure of mines and their related economic implications in a way that encourages sustainable development (DME, 2007; UN, 2002; DEA, 2011; DEAT, 2003; Danielson, 2006; DME, 2008; DWAF, 1999). Notably, South Africa as a mineral-rich nation has a long-established and economically significant mining industry (Global Mining, 2002). It may be one of the most suitable locations to experiment with sustainable mine closure and the development of viable mining closure frameworks (DEA, 2010; CoM, 2011; Stats SA, 2012; Global Mining, 2002).

Mine reclamation is aimed at restoring land to a stable condition that guarantees safety of the public, and to minimise potential negative environmental impact, and to allow for alternative land use prospects (Kubit et al. 2015; Heikkinen et al. 2008; Sheoran et al. 2010). This includes several landscape and geophysical alterations, which differs substantially from surrounding landscapes. Furthermore, post-mining sites can also include buildings, above ground and underground structures, as well as machinery (Rigina, 2002; Wirth et al. 2012). Mine closure and rehabilitation have become a core part of the mining life cycle planning and implementation.

The environmental management plan (EMP) for a mining activity should provide commitments to achieve broader end land use objectives. These are unrealistically linked to reinstating the post-mining land use with an expectation which often suggests that the rehabilitated land will have capabilities like the pre-mining land use capabilities (Hattingh, 2018). However, since mine land rehabilitation becomes inherently more challenging as the level of disturbance increases, this often results in flawed and expensive processes that seek to reconstruct landscapes according to physical environments and associated ecological functions (Doley et al. 2012).

In general, closed mines keep creating environmental risks such as acid mine drainage (AMD), heavy metal related mobilisation, decreased fertility of soil, and ground erosion, in certain instance this could be continuous (Limpitlaw et al. 2005). Closed mines sometimes try to avoid supportive potential land use at the expense of functioning ecosystems and human safety and wealth (Robertson & Shaw, 2006). Thus, mine closures are often poorly scheduled, which can lead to more serious socio-economic effects.

1.9 STUDY PLAN AND STRUCTURE OF DISSERTATION

The following chapters are applicable to this dissertation:

Chapter 1 Introduction and motivation: This chapter provide an introduction and the background to research. The problem statement and research objectives as well as the significance of the research, scope, and limitations are presented. It further includes the content analysis of chapters in the dissertation.

Chapter 2 Literature review: The chapter entails the reviewing of mining EIA reports as well as their relation to other documents, such as EMPs. A review of sustainable development and mining nexus is presented. Furthermore, opportunities and risks of post-mine closure, as well their link with the post-mining economy is researched and presented with references drawn from academic journal articles, textbooks, and other academic sources, such as conference papers and periodicals.

Chapter 3 Research methodology: The chapter presents the study research approach (qualitative) used in the dissertation. Firstly, an assessment was carried out on the selected EIA reports by evaluating the legal framework and processes. Secondly, analytic criteria were used for the comparative analysis of EIA reports.

Analytic criteria used are grouped under two categories namely, systemic and foundation measures, and are based on those proposed by Leu et al. (1997); Balsam & Wood (2002); and Wood, (2003).

Chapter 4 Results and analysis: This chapter presents the reviewed data, synthesis with discussions and the results interpreted.

Chapter 5 Conclusion: This chapter entails summary of the research and the recommendations that were made.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

In global practice, mine closure planning and environmental impact assessment are well-developed key procedures that seek to ensure that stakeholders and mining companies achieve sustainability aspirations (ICMM, 2008). It is often an expectation that mine closure planning should be an integral part of the life cycle of mining, from the original project layout to the mining authorisation evaluation; execution, decommissioning, and ultimate completion (IFC, 2007; Sweeting & Clark, 2000; ICMM, 2008).

The fundamental principles for adaptation and mitigation of environmental and socio-economic variables in the EIA reports, notably, Sanchez, et al. (2014) in various respects, established strong links between environmental impact assessment and mine closure planning, demonstrating the significance of identifying environmental and socio-economic effects of mining, together with the implementation of suitable mitigation, and monitoring procedures in the development of the EIA for prospective mining operation. This chapter presents a range of insights related to post-mining land use planning and sustainability.

Firstly, to assess the sustainability of post-mining land use planning for South African mining sector, which is the focus of this study, a review of, *inter alia*, literature, regulatory framework, and the sector norms, as well as global perspective on mine rehabilitation was needed to establish the current practices in the local context and worldwide solutions to post-mining land use planning.

Secondly, I took cognisance that mining is known to have impacts on the sustainable development goals (SDGs) as indicated in Figure 2.1; therefore, I considered a topic for sustainability and mine rehabilitation, and made a connection between sustainability and mining.

Thirdly, the fact that sustainable post-mining land use would have a positive spill-over effect on the South African economy (as shown in Figure 2.2: SDGs and post-mining land use linkages) was considered. I also took into account how post-mining land use aligned with the National Development Plan (NDP), as well as the African Mining Vision (AMV) specific impact indicators, and these were presented in Table 2.1.

The fourth area that I focused on in this chapter, includes mine rehabilitation, where some cases were discussed, with suggestions on the practicalities and benefits of sustainable mine rehabilitation drawn from various sources, including Anglo American's mine closure toolbox. The next topic in this section also provided context to the concept of land use planning and land use classification for the mining sector as well as reference to the classification used by the South African Department of Agriculture, Forestry and Fisheries (DAFF), and a comparative analysis was presented.

Furthermore, the section highlighted closure planning and post-mining economy, including instruments for planning (ecological-economic zoning (EEZ), analytical hierarchy process (AHP) technique, sustainability analysis, etc) and decision-making for post-mining sustainable development. The identification of opportunities and risks of post-mining economic proposals also form part of this chapter, followed by summary.

2.2 SUSTAINABILITY AND MINE REHABILITATION

2.2.1 SUSTAINABILITY AND MINING

The United Nations Sustainable Development Goals (SDGs) reflect evidence of a growing consensus that sustainable development must be considered in a holistic manner (Ekener, et al. 2018), rather than considering environmental and socio-economic impact in isolation. Management of mining in the interests of sustainable development, implies that environmental impact induced by emissions, subsidence and such variables should be restricted (environmental aspect) (Kretschmann, 2018).

The cost of managing mining damage should be maintained as low as feasible (financial aspect) (Stacey, et al. 2010) and the population residing in the mining areas should be given future opportunities for ensuring their standard of living and well-being after mining has come to an end (cultural aspect) (Azapagic, 2004). These methods for addressing the different aspects of sustainability can readily be transmitted to post-mining operations (Stacey, et al. 2010; Azapagic, 2004; Ackerman, et al. 2017).

Sustainable development indicators for the mining sector should lead to sustainability challenges being quantified into measures of economic, environmental, and social performance that focus on addressing vital concerns that accompany mining (Azapagic, 2004).

Mining operations by their nature entail that geological and ecological systems are interfered with and cannot be restored to their original condition (Kretschmann, 2018; Kretschmann & Hegemann, 2012). To physically restore mine lands is not enough because socio-economic impact of the mine closure also requires assessment and management (Limpitlaw, 2004; LeClerc & Keeling, 2015). Therefore, the adverse impact of mine closures warrants a comprehensive technique to examine various dimensions that are associated with mine closure including measures to mitigate its socio-economic effects (Ackerman et al. 2017).

Studies have illustrated that the spatiotemporal scheduling and execution of the rehabilitation and land use operations keeps changing all through the mining lifespan (Antwi, et al. 2008; Baral, et al. 2014), it also means that modifications of appropriate measures must be an essential part of this scheduling, enhancing the path to achievement, as different location information and understanding become accessible (Bateman, 2009). According to the Aboriginal Affairs and Northern Development Canada (AANDC) and the Land and Water Boards of the Mackenzie Valley (MVLWB) (2013), rehabilitation operations must be carried out as soon as the site development begins (progressive rehabilitation) and should be retained across the entire duration of the functional and demobilisation phases.

Notably, these operations remain much more significant to the tracking and monitoring phase where the effective execution of the already established asset utilisation can be proved. Thus, if the government is unwilling to give completion permits, mining corporations will proceed to pick post-mining types that give the biggest probability of abandonment instead of the most viable land use (Boyer, 2015; Cao, 2007). The post-mining structure for land use, considered as part of this dissertation, emphasises the need to examine project-specific choices within the context of national land use planning, as well as the cultural, political, and stakeholder views that support sustainable post-mining land use planning, implementation, and monitoring.

From a historical perspective, it has been argued that the South African mining sector generally has a silo approach to addressing the severe impact that mine closure has on the society, environment and the industry (Ackerman et al. 2017). Planning for a mine closure should thus focus not only on rehabilitating the environment, but also on the various socio-economic aspects of closure.

Ackerman, et al. (2017) further suggest that appropriate action would include a budget that provides for the added financial burden to mining companies when planning proactively for a possible mine closure. Hence, a progressive development approach, such as the sustainable development goals (SDGs) would have a development framework with economically viable activities, which the mining companies could embark on comprehensively (Starke, 2016; Atlas, 2016).

Figure 2.1: Mining and the 17 SDGs. Source: Mapping Mining to the Sustainable Development Goals: A Preliminary Atlas. Available at http://unsdsn.org/wpcontent/uploads/2016/11/Mapping_Mining_SDGs_An_Atlas.pdf.

The silo approach of addressing the impact of mine closure, mentioned by Ackerman, et al. (2017), is not peculiar to South Africa but an unfortunate trend across the African continent, as demonstrated in multiple evidence from literature and policy documents at continental and regional levels in Africa. These sources seem to suggest that the primary focus, for most mining countries on the African continent is on enhancing governance mechanisms aimed at attracting foreign direct investment (FDI) and related opportunities for leveraging resource development (African Union (AU), 2009, 2013; United Nations Economic Commission for Africa and African Union 2011; African Union Commission, 2012; African Development Bank, 2012, and United Nations Economic Commission for Africa 2012) with little or no attention to mine closure planning.

The National Development Plan (NDP) 2030 of South Africa emphasises the desire to diversify the country's economy. It acknowledges that agricultural operations should be broadened to reduce the high levels of unemployment and poverty in rural communities and that sustainable agriculture should be the central focus. However, with the predominant patterns in the expansion of surface coal mines to accessible arable land, it may not be possible to achieve this goal (Botha, 2014).

The style in which rehabilitated locations are managed can have a significant impact on the achievement of the incorporation of the site within the functional post-mining land use setting. For instance, the residual mineral resources are often illegally re-accessed by artisanal miners after the mine has been shut down, which could lead to hazardous or even deadly outcomes. Rehabilitation of mine fields is most often misused by landowners, who overgraze the mine land, then blame the mine and request government assistance (Limpitlaw et al. 2005). This sort of misuse is frequently connected with rehabilitated mine land that is rented out, showing the typical situation of tragedy of the commons (Limpitlaw, et al. 2005).

In many mining jurisdictions, and particularly in Africa, mining constitute an opportunity for much needed socio-economic development, and the awareness of the importance of managing environmental resources to promote sustainable mining is therefore recognised and championed by high-level policy instruments, such as the action plan for implementing the African Mining Vision (African Union Commission, African Development Bank, and United Nations Economic Commission for Africa, 2012), which supports:

- “a mining sector that is knowledge-driven and is the engine of an internationally competitive African industrial economy;
- a sustainable and well-governed mining sector that is inclusive and appreciated by all stakeholders and surrounding communities; and
- increasing the level of investment flows into mining and infrastructure projects to support broad socio-economic development”.

Table 2.1 provides an overview of how post-mining land use planning is connected to selected global, continental and national development plan. Similarly, figure 2.2 indicates post-mining land use linkages to the sustainable development goals (SDGs). This serves to underscore the positive spill-over impact of sustainable post-mining land use planning to development.

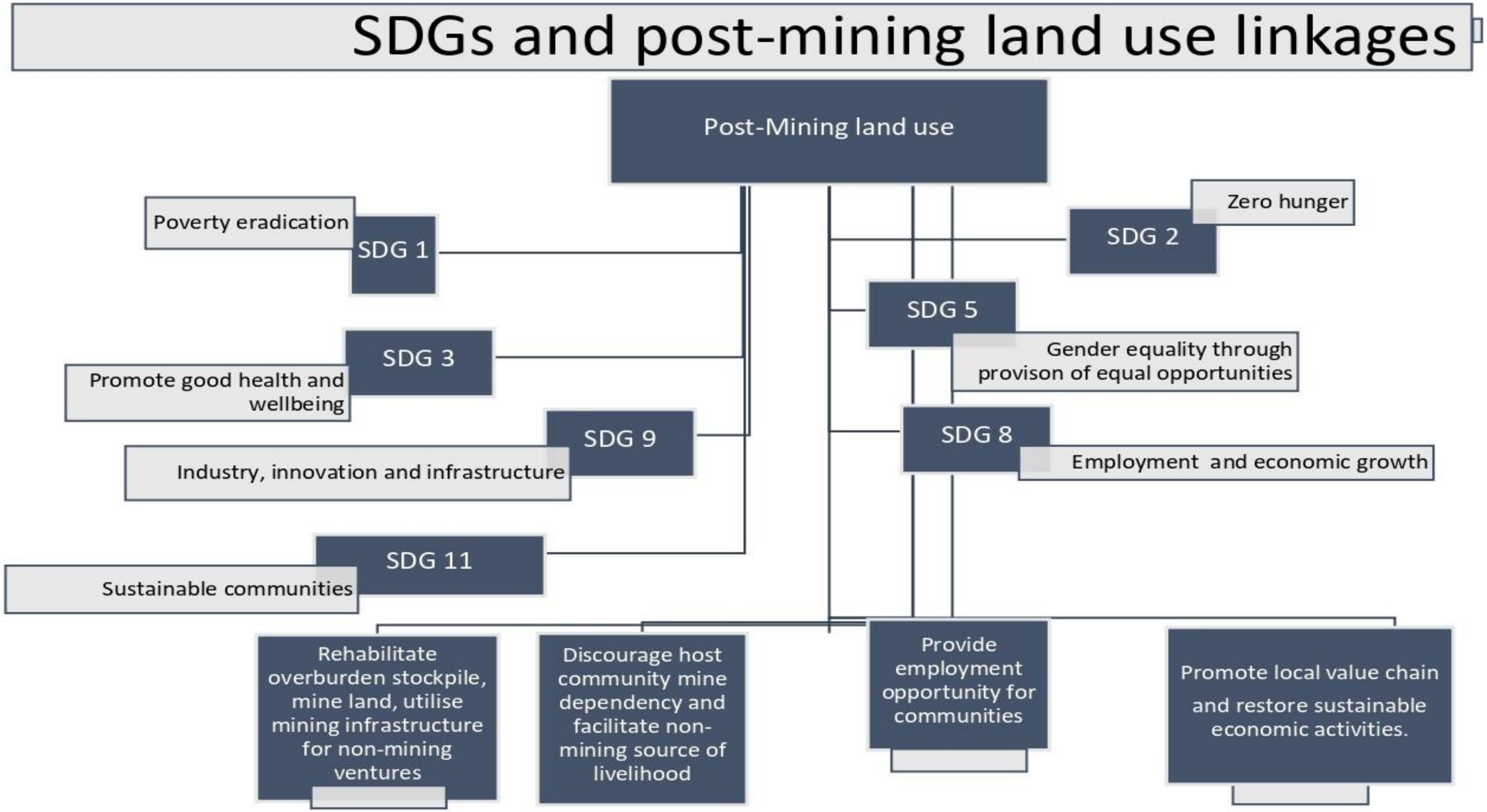


Figure 2.2: SDGs and post-mining land use linkages. Source: Author's own concept

Table 2.1: Post-mining land use impact indicator on selected global, continental, and national plans. Source: Author's own concept.

Post-mining land use: Selected impact indicator on sustainable development goals (SDGs), the African Mining Vision (AMV) and the South African National Development Plan (NDP)		
SDGs 1 and 2	Poverty eradication; zero hunger	
SDG 3	Promoting good health and well-being	NDP chapter 6, inclusive rural economy
SDG 5	Gender equality through provision of equal opportunities	
SDG 8	Employment and economic growth	NDP chapter 3, employment and economic opportunities.
SDG 9	Industry, innovation, and infrastructure	NDP chapter 5, environmental sustainability and resilience.
SDG 11	Sustainable communities	
African Mining Vision (AMV)	Post-mining land use impact on the African Mining Vision (AMV) is in the AMV programme cluster number 7, which addresses environmental and social issues. The AMV is a comprehensive document, but within the scope of this dissertation, we are interested in cluster number 7 as it focuses on a mining sector that is environmentally friendly, socially responsible and is appreciated by communities. The African Mining Vision (AMV) action plan is available at https://www.chr.up.ac.za/images/researchunits/bhr/files/amv_action_plan.pdf.	

2.2.2 MINE REHABILITATION

As a result of the finite nature of ore resource, mine closure including related post-closure social, environmental, and economic characteristics, are considered life cycle of mining activities (Limpitlaw, 2004). In South Africa, many mines, especially coal mines around Mpumalanga, have for some time been expected to be in a decline as the major operations in the industry is shifting towards the Waterberg (Choshi, 2001; Mohring, et al. 2001; World Bank, 2002). In the past few years the rate of closure of gold mines on the East and West Rand has also accelerated. Not only do mining operations degrade the environment but their closure also triggers negative spiral effects, such as distressed communities grappling with the resultant unemployment and poor living conditions (Stacey et al. 2010). For instance, the closure of some Lonmin's mines in South Africa could result more than 12 000 job losses over the next three years (Lechela, 2018; Steyn, 2018).

Although the effects of mine closures are often understated and nuanced, many mine towns end up as ghost towns as the departure of mine companies often results in the closure of various other service industries (Steyn, 2018; Lechela, 2018; Macfarlane, 2018). One such a ghost town is the once vibrant town of Kolmanskop, situated within the Sperrgebiet National Park on the southwest coast of Namibia, which became desolate at the end of diamond mine production in the area (Alexander, 2010).

A pertinent question that arises in relation to the sustainability of mining legacies is the type of post-mining land use activities that rehabilitation can support (Mborah, et al. 2015; Maczkowiack, et al. 2012). In the same vein Alexander (2010) poses a similar question in his research project about Kolmanskop, whether the abandoned mining area, which is now dubbed a “ghost town”, is also able to fulfil the criteria of an industrial heritage resource. To a large extent, the decision for the most suitable land use is propelled by profile of the abandoned mine area, expert opinions, development plans of local communities and authorities, legal environmental framework, and restrictions (Heikkinen et al. 2008; Slingerland & Wilson, 2015; Kuter, 2013; Palogos et al. 2017).

In developing countries, mining is increasingly occurring in remote areas where there may be significant need for social amenities and infrastructure; and the costs of restoring land to low (economic) value pre-mining use may be far greater than establishing a viable post-mining land use (Limpitlaw & Briel, 2014). Figure 2.3 shows a value-based driver for post-mining rehabilitation, and how establishing post-mining land uses could assist in mitigate the inevitable loss of employment that results from mines closure. An explanation of the land capability classes (in roman numeral) is provided in table 2.2.

Maximising post-mining value of mining infrastructure could significantly contribute to postmining economies (Limpitlaw & Briel, 2014). For example, at a gold producer in a small Pacific island state, mine's sports facilities were considerably better than those in nearest regional centre because the facilities have enabled local teams in the community to participate in sports at both the national as well as international levels (Limpitlaw & Briel, 2014). Part of closure planning challenge is how to find effective ways of maintaining such facilities once they are handed over to community after mine closure. Similarly, in a country with a tourism-focused economy, and the establishment of heritage tourism sites, using old mine buildings and equipment is possible, as the case in one such notable successes in heritage tourism reported at the site of the former Waihi Gold Mine in New Zealand (Thompson, 2011).

At a copper producer in Katanga, in the southern Democratic Republic of Congo (DRC), the company's accommodation facilities present an opportunity for reuse, post-closure as a training and conference venue as they are within easy driving distance of Lubumbashi, the provincial capital. The attractiveness of this land use option is reinforced by looking at ways of maximising use of the mine's power and water reticulation infrastructure.

Light industry is already establishing itself on the outskirts of Lubumbashi, and by the time the mine closes, it is likely that the site could act as an industrial development incubator. This approach is already being adopted by some multinational mining companies. For example, in Anglo American's mine closure toolbox it is argued that exploitation of mineral resources should also contribute to the infrastructure base and provide an economic stimulus for sustainable development in the host region (Anglo American, 2013).

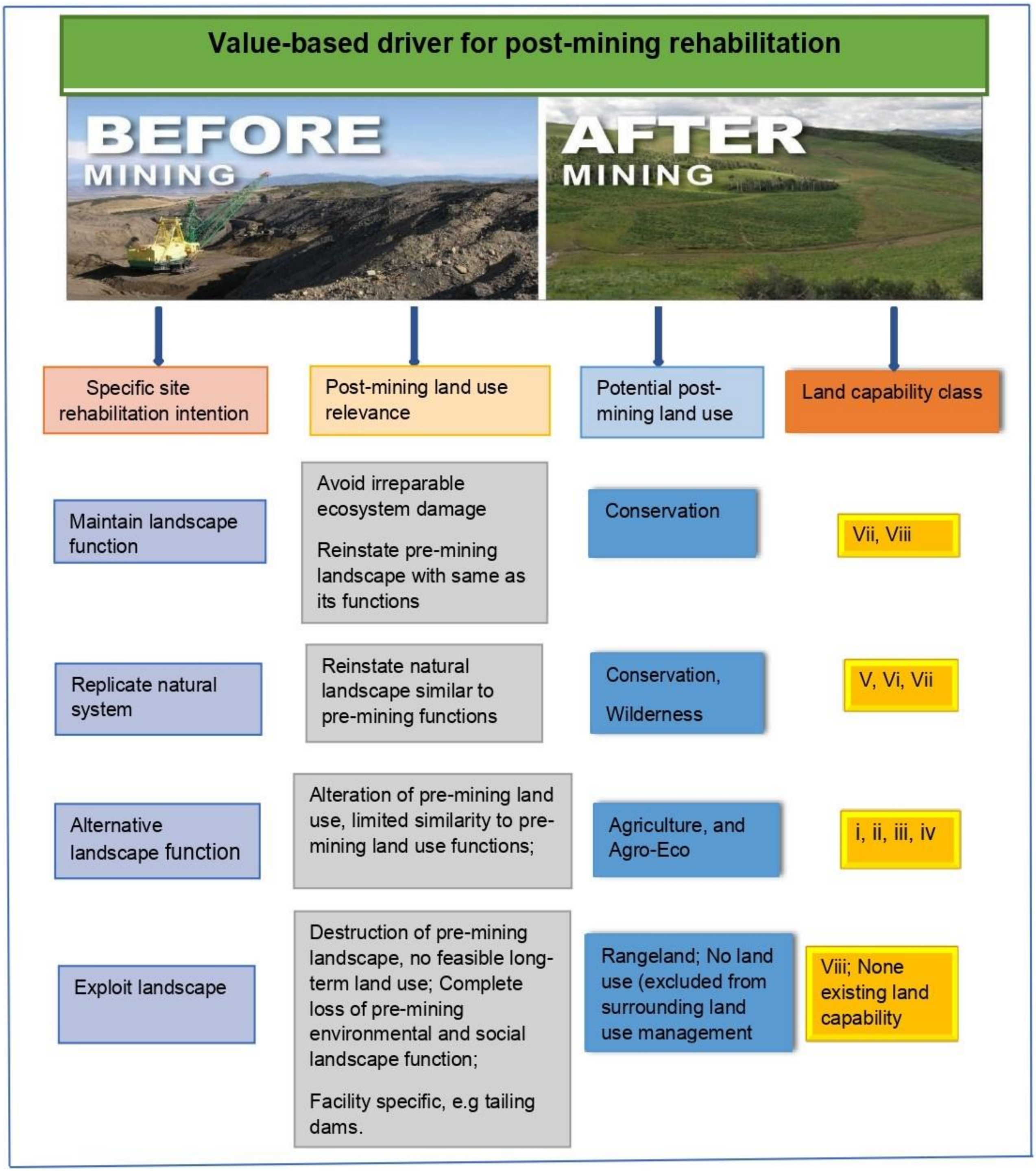


Figure 2.3: Value-based driver for post-mining rehabilitation. Adapted from Doley et al. (2012).

2.2.3 THE CONCEPT OF LAND USE PLANNING

Many of the concepts associated with mining-related land use, for instance restoration, rehabilitation and ultimately mine closure planning, often seem to be misunderstood. Although the primary objectives or intention may be comparable, each concept involves intervention that needs specific planning consideration for post-mining land use (Hattingh 2018). According to the International Council on Mining and Metals (ICMM, 2011), land use planning involves a comprehensive evaluation of land and water capacity, including the socio-economic contexts for selecting and adopting the most feasible land use options.

This process aims to select and fully implement those land use options that will best meet people's needs while seeking to protect resources for the long-term (ICMM, 2011). Even though the objectives of land use planning are often determined by socio-political considerations, it must take into consideration the current scenario in the affected communities because the driving factor behind land use planning is the need for change, the need for enhanced management, and perhaps even the need for a completely distinct model of land use that responds to the need for change (Hattingh, 2018).

According to the South African Chamber of Mines (2007), land capability as a component of land use planning relates to the capacity of land, based on its material and environmental characteristics. The South African Department of Agriculture, Forestry and Fisheries (DAFF) have an established and documented eight land capacity groupings, as shown in Table 2.2. Classification of land capacity is an illustration of the impact of physical variables on plant suitability and prospects that enable routine tillage, pasture, agriculture, and fauna without destroying the resource, thus, all land uses involve a specific land capacity or a combination of land capacity to be successfully deployed.

Table 2.2: A comparative analysis of DAFF and mining sector land capability classes Source: Adapted from Bureau for Food and Agricultural Policy (BFAP, 2015).

Land capability class	Soil depth	DAFF land classification	Mining sector classification
I	>800	Arable land suitable for very intensive cultivation	Arable land
II	>700	Arable land suitable for intensive cultivation	
III	600 – 800	Arable land suitable for moderate cultivation	
IV	500 – 700	Arable land suitable for light cultivation	
V	400 – 600	Grazing land suitable for moderate grazing but not for forestry	Grazing
VI	300 -500	Grazing suitable for moderate grazing	
VII	100 – 400	Grazing land suitable for light grazing	
VIII	<100	Wildlife	Wilderness Wetland

2.3 CLOSURE PLANNING AND POST-MINING ECONOMY

2.3.1 CLOSURE PLANNING

Mine closure practices that started developing in the late 1960s and early 1970s in countries with advanced economies and mature mining industries, is influenced by the way it is implemented by companies and regulators (Limpitlaw & Briel, 2014). For instance, in Canada planning of reclamation was entrenched in law in 1969 when British Columbia became one of the first mining jurisdictions to introduce mine reclamation legislation (Bowman & Baker, 1998).

In these settings, the emphasis was justifiably on restoration of the landscape and an attempt was made to return to the natural pre-mining land cover (Limpitlaw & Briel, 2014) and this continued to evolve and incorporated socio-economic and cultural aspects, especially after the Brundtland Report in 1987 and the subsequent Earth Summit in 1992.

Mine closure plans are usually conceived in non-social terms and primarily from an environmental perspective (Slingerland & Wilson, 2015). They are frequently not an integrated part of planning for the whole lifespan of the mine from the mine development phase and onwards (Jolliffe & Conlin, 2010). This often results in a misalignment among closure, production, and safety goals (Andrews et al. 2005; Azapagic, 2004; Kretschmann, 2018). Closure planning is often viewed as a crisis management exercise, and the plans tend to overemphasise or focus on physical, biophysical, or environment planning, at the expense of socio-economic aspects and human resource development (Laurence, 2006; Andrews et al. 2005).

At the end of mining operations, those mines that are inadequately closed or abandoned could persistently contaminate water bodies, surrounding land, as well as the air (Gutierrez, et al. 2016; Kim, et al. 2016; Venkateswarlu, et al. 2016). There are many mines globally where proper mine closure processes did not take place and sometimes were not completed (McHaina, 2001; Fields, 2003; Pepper et al. 2014; Keeling & Sandlos, 2017).

Impending mine closure inevitably has far-reaching consequences for the miners, communities, mining companies and different government structures (Marais, 2013). In general, role-players seem to be consistently ill-prepared to deal effectively with this final phase of the life of a mine, and invariably fail to generate post-mining economies.

According to Marais, (2013) it is possible to identify seven main consequences of mine downscaling or closure, on the basis of existing literature:

- mine downscaling or closure is closely linked to upheaval, instability and conflict in mining settlements. The period of decline that precipitates mine closure warrants as much attention as the mine closure itself, as this is the time when a mining community is most likely to experience community instability and division.

- depending on the age, health and level of skill and/or education of community members, the impact of mine downscaling may be experienced in different ways. This became evident in the mining communities, if workers decide to utilise an exit strategy and the town loses its most resourceful workers, this implies that economic goals were met at the expense of regional goals.
- community instability is exacerbated in towns where the heavy subsidising of services by the mining company has resulted in an artificially high standard of living that has encouraged workers to remain. Where the mining company is a major property owner and contributes to the municipal budget through subsidies and property tax, not only does the impact of a possible mine closure affect the miners, but the economic stability of the wider community is also compromised. One of the main problems of mine closure is that in many cases, local authorities are required to take over the social and infrastructure services when mines close.
- many post-mining communities have to live with the environmental consequences of mine downscaling including the fact that many of the environmental impacts remain and the ecological footprint continues despite downscaling. mine closure also has significant impacts on other types of infrastructure and the overall housing environment. mine closure has been found to negatively impact on the telecommunication infrastructure, schools and health facilities. These infrastructure has been created for the mining communities. Mine housing is common in many mine areas; and the closure of a mine usually leads to people losing such benefits.
- community commitment to self-help may be adversely affected by a lack of entrepreneurial tradition and a history of company dependence. Resourceful individuals who could effectively mobilise community action may be the first to leave in order to secure alternative employment. Local communities in rural areas often give up agriculture, hunting or fishing as they start to earn money from mining activity. They increasingly buy food instead of producing it and become overly dependent on the income from the mine to provide for their needs. When the mine closes, self-sufficiency and food security are drastically reduced for these communities.

- another factor that contributes to community instability and decline is the removal of capital by the mining company. The company may decide to establish another production line that is more competitive and profitable, thereby necessitating the relocation of profits and investment to the new plant. Older facilities at the first plant may be allowed to fall into disrepair, so that the depreciation allowance can be re-invested in the new plant. Machinery, marketing and profits are gradually relocated. In a single-industry town, with no prospects of alternative employment, out-migration by the workforce becomes the only viable option. In order to avoid the identified impacts, planning for a post-mining economy should start once the mine opens (Marais, 2013).

There is evidence that the benefits of sustainable, multi-functional use of natural and semi-natural landscapes exceed the gains from their conversion to single purpose land use types (De Groot, 2005) because natural landscapes commonly provide a multitude of functions and are subject to many possible land uses. Closure planning should attempt to create a post-mining landscape in which multiple land uses are possible, so that a level of sustainability more closely approximating that of the pre-mining landscape can be achieved. To approach such improved levels of sustainability, multifunctional post-mining landforms are required (De Groot, 2005; Sonja, 2017).

To maximise the benefit derived from post-mining landforms and to ensure optimal use of resources in the rehabilitation programme, the mine lease should be divided into several land use precincts.

These precincts are typically determined by the existing land use, current and future surrounding land uses, the nature of the topography, and the level of disturbance. A closure options analysis is required to identify closure options and select a preferred option for each precinct (De Groot, 2005). The preferred closure option will inform the direction of the closure strategy and closure cost estimate.

Mine closure planning should also relate to local economic development (LED) plans (Rogerson, 2014) linked to the integrated development plans (IDPs) of government, to ensure that mining end land uses are in sync with development initiatives. This broader view provides a context against which the investments of the mine in human capital and infrastructure can meet developmental needs and create a mechanism for economic growth, post-closure.

Post-mining land use is generally determined by economic, social, and technical factors as well as mine site properties (Palogos, et al. 2017). The suitability of an area for mining end land use would also base on, *inter alia,* the current land use surrounding the site, infrastructure, and facilities, and the extent of any environmental impacts, such as soil and water contamination (McHaina, 2001; Soltanmohammadi, et al. 2010; Edraki, et al. 2014; Palogos, et al. 2017).

According to Marais & Atkinson (2006) The effects of mine closure are further exacerbated by the fact that mining communities have several social characteristics that are unique to mono-industries. Although these characteristics are not generalisable, it is nevertheless necessary to consider certain degrees of prevalence of these characteristics within mining communities. Firstly, mining communities may not be strongly cohesive. There may be strong social cleavages between mineworkers and non-mineworkers within the community. There may also be strong divisions between the mineworkers' union and the company.

Secondly, owing to the high level of dependency on the mine, there may be a lack of both entrepreneurial tradition and experience in a mining town. Thirdly, due to the support provided by a mine and the relative prosperity of mining towns, local government bodies might be less pro-active in community development than where mines are not present. Fourthly, those community members who are most able to mobilise community action and to support local development, are also those who are most likely to leave the town once a mine closes.

Marias & Atkinson (2006) further argue that:

- It has become almost axiomatic that many South African municipalities have "inadequate capacity";
- While some IDPs have become excellent guides to development, many other IDPs are still poorly drafted. Relatively few IDPs, as yet, have a meaningful focus on economic development. However, it should be noted that the quality of IDPs appears to be improving steadily.
- The public participation processes underpinning many IDPs have been inadequate. Many key local constituencies (such as commerce and mining) have not been included in the debates leading to the drafting of IDPs. Many IDPs are biased in favour of lobby groups representing the poor, in particular

black township residents, but they are often biased against rural constituencies (such as farmers or farm workers). Furthermore, many municipal Councillors still harbour a distrust of the private sector, and this leads to a systematic bias in Council decisions.

- What seems missing from the South African situation, thus far, is the active involvement of central government in dealing with mine closures. It appears that central government has done virtually nothing to alleviate these crises. In the Free State, the provincial government has shown little interest in the plight of the Goldfields. This shows the need for issues of mine closure to be put much higher on the government agenda. To expect municipalities to carry this burden, often at a time when their rates base is being undermined, is completely unrealistic.

Mines can also be reopened, for example, as a result of higher mineral prices or new technologies (Laurence, 2011; Haque, et al. 2014). However, there are no universal reclamation planning schemes for former mining areas, and thus, detailed objectives of closure plans and post-mining measures are largely site-specific (Audet, et al. 2013; Lamb, et al. 2015).

2.3.2 POST-MINING ECONOMY

Most mining companies view closure and reclamation planning as an integral part of the operating plan (Slingerland & Wilson, 2015; McHaina, 2001), and globally a range of industrial developments, as well as heritage tourism, (that is tourism at man-made sites, buildings, and landscapes including industrial processes) have been developed on abandoned mines (Wirth, et al. 2012; Edwards & Coit, 1996; Jolliffe & Conlin, 2010).

There will always be differences in pre-mining and post-mining ecosystems and landscapes (McHaina, 2001; Simmons, et al. 2008) but the most common post-mining land use purposes include agriculture, forestry, recreation, construction, conservation, and lakes (McHaina, 2001; Soltanmohammadi, et al. 2010). Although the perception of post-mining landscapes is often negative, they can harbour unique natural, cultural, and economic potential (Wirth et al. 2012).

Examples of these are pastures, aquaculture, wildlife habitats, educational, and industrial uses (Maczkowiack, et al. 2012; Soltanmohammadi, et al. 2010), sport and leisure facilities or tourism (Jolliffe & Conlin, 2010; Bailey & Hooey, 2017).

In addition, where appropriate, a post-mining area can be maintained as an industrial complex and the mining infrastructure could be reused (McHaina, 2001; Kubit, et al. 2015). Some researchers (Lei, et al. 2016; Otchere, et al. 2004; Miller, 2008; Bangian, et al. 2012; Soni, et al. 2014) also show in various ways that post-mining sites that were restored could include activities that were not historically related to mining. There is a growing interest in mining countries to utilise abandoned mines, particularly open pits, for various purposes that could enhance socio-economic development, such as aquaculture, aquatic sports, and other recreation (Harfst, 2015).

2.3.3 EIA REPORT FOUNDATION PERFORMANCE MEASURES FOR POST-MINING LAND USE

The book "101 Things to Do with a Hole in the Ground" by Pearman (2009), published by the Post-Mining Alliance in collaboration with the Eden Project, presents internationally promising, actual examples of repurposed post-mining land uses that, with careful planning, have been generated by paradigm shifts and have proven to be effective. Given the achievements of rehabilitated post-mining landscapes, it is crucial to establish which vital land use characteristics describe the pre-mining ecosystem, and how many of these terrain characteristics remain throughout the post-mining setting, and their authenticity (Doley et al. 2012). It is therefore not out of place to assume that an EIA report, such as those reviewed in this dissertation, could provide an unambiguous evaluation of whether these mine land characteristics can be sustainably restored post-mining.

2.3.4 POST-MINING LAND USE: INFRASTRUCTURE, AGRICULTURE AND ENERGY NEXUS

In order to generate possibilities for sustainable jobs, creative enterprises on post-mining land would involve excellent infrastructure – offices, business assets, convenient and aesthetic recreation places, and cultural amenities (Pearman, 2009). For instance, similar to the Eden Project in the United Kingdom, a German real estate firm used its knowledge to help convert former coal mining areas into industrial parks, offices, ski rides, and other associated applications (Australian Bureau of Agriculture and Resource Economics and Sciences, 2011; Australian Department of Industry, Tourism and Resources, 2006).

Large-scale mines are mostly situated in rural areas of developing economies, where agriculture is the main source of local livelihoods. In many instances where landowners cultivate plant species on mineralised soils, yields are not profitable (Brooks & Robinson, 1998; Brooks, et al. 2001). Internationally, agricultural production is experiencing an increasing need for the production of food, bio-based power and fibre goods (Gutzler, et al. 2015). Transitioning farmers to expanding their supply may include adjustments in plant selection, crop rotation, crop usage, and an increase in efficiency. According to a report by the Bureau for Food and Agricultural Policy (BFAP), from a mining view, rivalry for natural resources is most evident where extraction of minerals and agriculture strive for heavily valued land resources (BFAP, 2015).

Mining firms have started using creative methods that combine renewable energy with biogas and land rehabilitation at the same time. Mining companies may consider several post-mining asset uses, such as the development of carbon sinks and the transformation of rehabilitated mine land into energy-growing plantations for the manufacturing of sustainable biogas to feed other sectors (Kotze, 2014).

As an instance, Kotze, (2014) noted that in South Africa, Harmony Gold Mining Company has created a sustainable land rehabilitation plan related to the creation of carbon sinks on mine-impacted land. Instead of pursuing conventional land rehabilitation methods such as grassing, Harmony’s plant species, like sweet sorghum, sugar beet, and large king grass, are renowned for their elevated energy sequestration capacity. Harmony's rehabilitation approach also involves planting energy crops on mine-impacted soil with zero economic value. Once cultivated, these plants can be transformed into renewable energy in the form of biogas, through an anaerobic digestion method. Biogas will be used to substitute carbon fuels in Harmony’s metallurgical plants (Kotze, 2014).

Anglo Platinum's nickel (Ni) phytomining operation at the Rustenburg Base Metal Refinery in South Africa, illustrates a different approach to mine rehabilitation. The company hired local farmers to obtain *Berkheya coddii* seeds, naturally grown in the region. Farmers then cultivated the hyperaccumulator seedlings on contaminated soil, and the biomass was then harvested, bound in packs, and supplied straight into the nickel smelter.

The mine land has also been rehabilitated through this process, and nickel from the biomass was integrated into Anglo Platinum's high-volume metal product (Brooks, et al. 2001; Robinson et al. 2015).

Within the South African context, most mine rehabilitation ventures are focused more on addressing the safety, health, and environmental challenges presented by abandoned mines. Initiatives that could benefit the post-mining economy in the mining communities, which could have direct linkage with some of the sustainable development goals (SDGs), are often neglected. However, things are beginning to change as sustainability issues relating to post-mining receive attention globally (Li, 2006; Ranangen, & Lindman, A., 2017).

Nonetheless, most mines continue to be abandoned after the production phase without consideration of the potential risks to humans and the environment or socio-economic dimensions (Sandlos & Keeling, 2016). This usual way of doing things is suboptimal and reduces the ultimate contribution of a mine to long-term sustainability in developing countries (Limpitlaw & Briel, 2014).

The implementation of a post-mining rehabilitation programme is intended to ensure safety as well as reducing the environmental impact of mine closure. In the absence of such mitigation measures, it is inevitable that adverse environmental impact would persist (Heikkinen, 2008; Kivinen, 2017). The various stages of a mine's life cycle, particularly the production phase, have a significant adverse environmental impact (Kotilainen, et al. 2015; Redondo-Vegas, et al. 2017).

In locations where mining activities take place, these adverse effects may last anything from 50 to 100 years. The duration of the impact is highly unpredictable because closure is often prompted by many factors, such as when the resource is depleted or exhausted, or in situations where mining is no longer economically profitable, due to high operational cost or unprofitable commodity market prices (Laurence, 2011; Haque et al. 2014).

Underground and open-pit mining change the landscape, and have significant impact on vegetation, and the indigenous ecosystem. Local communities in mining areas are therefore usually faced with various challenges, inter alia, poor environmental quality, as well as socio-economic issues (Kivinen, 2017).

Sustainable development initiatives are further compromised because of increasing levels of unemployment and corruption, consequently services provided to the community by the mines cannot be sustained after mine closure, leading to the socio-economic breakdown of mining communities, characterised by crime and poverty (Marais, 2013).

2.4 INSTRUMENTS FOR PLANNING AND DECISION-MAKING FOR POST-MINING SUSTAINABLE DEVELOPMENT

2.4.1 INSTRUMENTS FOR POST-MINE LAND USE PLANNING

According to Han & Zhang (2014), the connection between a land planning-related directive and mine rehabilitation can be achieved through a multidisciplinary approach, along with a wide range of practical planning that involves interested and affected parties (I&APs). For instance, Brömme, et al. (2014) noted that in the Hon Gai region of Vietnam, mine end land use initiatives for the country's largest coal mining company, mapping of the area, and a stakeholder-inclusive approach was used for post-mining land use planning. This included:

- Compilation and assessment of data on authorised proposals;
- Agreement about the need for the inclusion of varying regional and local plans;
- Land use planning as a visual method, considering many distinct spatial variables that are interconnected. As a result, a compilation of planning maps was available to assist the planning method and associated stakeholder engagement; and
- Interactions among various stakeholders, and the integration of post-mining land use planning with other local and regional plans, highlights importance of stakeholder consultation as well as the use of regional land use map to guide the detection of feasible post-mining land use before the start of mining operations;

The necessary planning information collected for the integrated planning of post-mining land use in the Hon Gai area had to include basic topographical data describing the current scenario as well as data forecasting the trends according to several existing plans from the interested parties (Brömme et al. 2015a).

The ultimate objective is to attain a position in which disputes around various types of land use from the mining companies, regulatory authorities, and interested parties are mitigated (Brömme et al. 2015b).

2.4.2 ECOLOGICAL AND ECONOMIC ZONING FOR LAND USE PLANNING

Ecological and economic zoning (EEZ) was used by Jeromino, et al. (2015) for land use planning (LUP) in Cajamarca-Peru, with the aim of identifying sub-areas for sustainable land use and conservation. Like the study conducted by Brömme, et al. (2015a), the EEZ applied in this context was also intended to balance distinct interests and proposals for land use through stakeholder engagement, technical knowledge, and GIS technology. Hattingh (2018) cited Sombroek and de Souza Carvalho (2000), and the Food and Agriculture Organization of the United Nations (FAO) as having used ecological-economic zoning (EEZ) (FAO, 1996) as an optimisation strategy for land use planning, to:

- Identify places where specific uses may be supported through advancement initiatives, inter alia, facilities and financial rewards;
- identify areas with unique requirements and challenges, as well as areas requiring security or preservation; and
- provide a foundation for the development of infrastructure (Hattingh, 2018).

2.4.3 POST-MINING LAND USE SUSTAINABILITY ANALYSIS

In Soltanmohammadi, et al. (2010), identification of feasible land use options was classified into cultural, economic, technical, and mine location indicators, with the main aim of establishing mining land suitability for post-mining land use.

This was done using the Mined Land Suitability Analysis (MLSA) model (Figure 2.4), established on the notion that rehabilitation of mines with the use of MLSA should be to identify appropriate post-mining alternative interventions and costs for the proposed rehabilitation (Mu, 2006; Zavadskas & Antucheviciene, 2006; Soltanmohammadi, et al. 2008b).

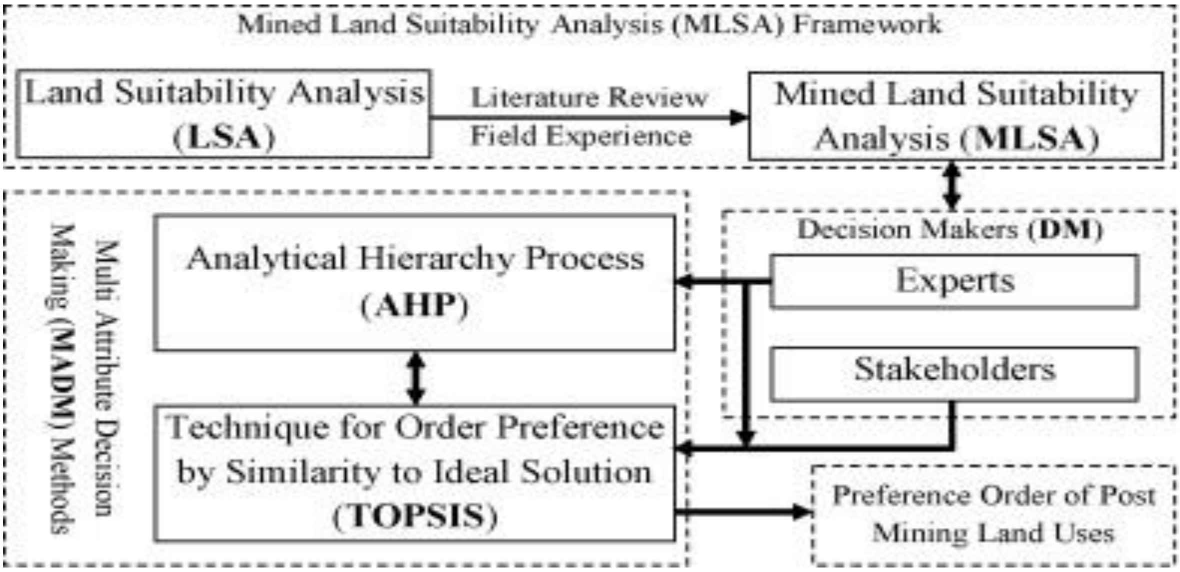


Figure 2.4: Multiple relationship between methods used for post-mining land use planning. Adapted from Soltanmohammadi, et al. (2010).

MLSA as a quantitative method using a mixture of two multi-attribute decision-making (MADM) tools can also be used to streamline the proposals for post-mining land usage (Soltanmohammadi, et al. 2009, 2010). MADM is a method used to resolve issues requiring the choice of a limited number of alternatives (Venkata, 2007; Akbari et al. 2006), and can ensure the sustainability of the larger scheme of things and the objectivity of the alternative because they are based on quantitative techniques (Soltanmohammadi et al. 2008a, 2008b). Figure 2.5 shows approaches to post-mining land use planning. These include focused upfront planning, land capability to supply services or use, and land suitability analysis, as well as underlaying philosophies, and commonalities across approaches.

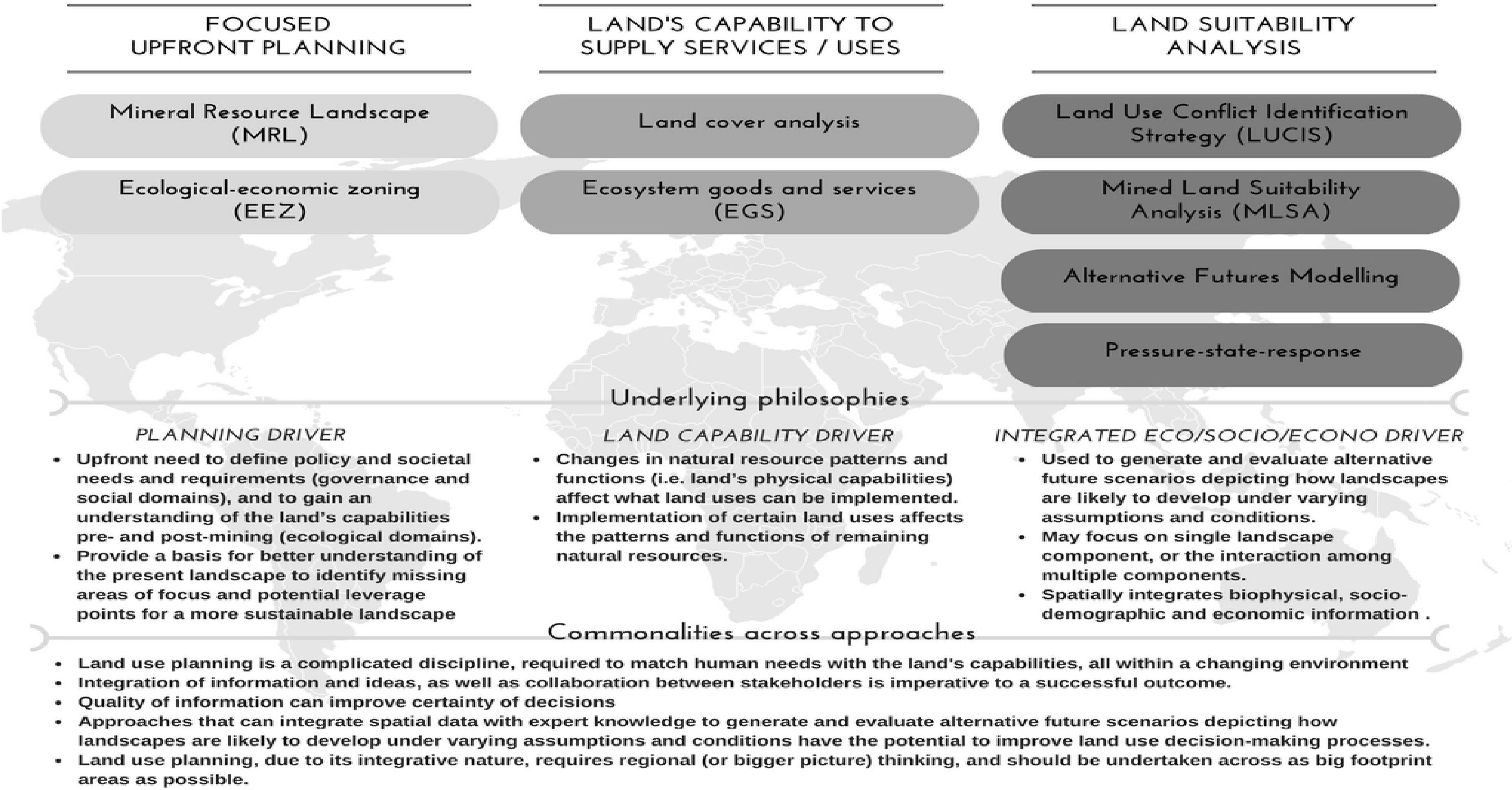


Figure 2.5: Approaches to post-mining land use planning. Source: Hattingh, (2018).

The analytical hierarchy process (AHP) technique was used to determine the weights of MLSA characteristics by pair-wise comparative matrixes (Figure 2.6) of each individual specialist proposal (Shih et al. 2007; Masoumi & Rashidinejad, 2011). Once the weight vector of the characteristics is calculated using AHP (Bascetin, 2007) they are integrated into the choice matrixes consisting of stakeholders (under expert guidance) and forwarded to what Bazzazi et al. (2011) referred to as "the technique for order preference by similarity to ideal solution (TOPSIS), also known as the distance-based MADM method that can determine the preferred order for post-mining land use (Masoumi & Rashidinejad, 2011).

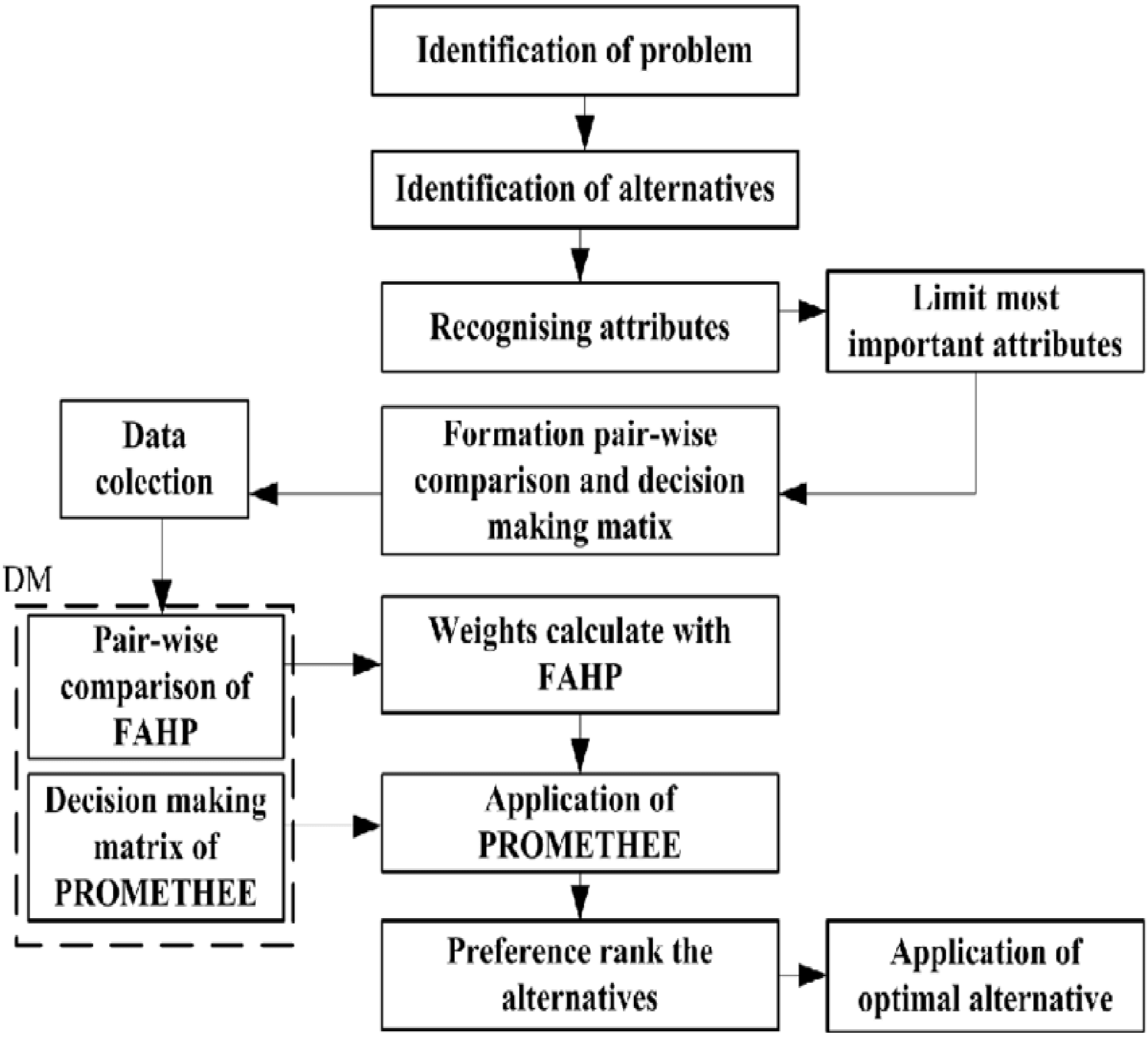


Figure 2.6: Comparative matrixes for post-mine land use planning. Adapted from Masoumi and Rashidinejad, (2011).

2.5 IDENTIFICATION OF OPPORTUNITIES AND RISKS OF POST-MINING ECONOMIC PROPOSALS

The adverse impact of mine closures requires a comprehensive approach to examine the various dimensions that are associated with mine closure as well as ways to mitigate its socio-economic consequences (Ackerman, Waldt & Botha, 2017). A broader consultation is required between the government, mining companies, and host communities. This process needs to commence at the design stage of the project (Limpitlaw, 2004; World Bank, 2002). The World Bank (2002) lists three requirements for this:

- early, constructive action by mining companies to ensure that the memory of mining is not one of negative environmental and social impact – a reputation that will increasingly threaten future mining operations elsewhere,
- proactive involvement by local communities to ensure that the benefits from mining are sustainable for future generations, and
- legal frameworks, with early planning and support to local communities by government, to ensure that the authorities are not left to manage large environmental and social problems.

Mine closure would require the restoration of land to a sustainable post-mining use, like agriculture but as earlier stated, to physically restore mine lands is not enough because socio-economic impact of the mine closure also requires assessment and management (Limpitlaw, 2004; LeClerc & Keeling, 2015). Where there is no definite or beneficial land use identified; areas restored to wilderness areas or unused conservation areas may attract undesirable post-closure land uses, such as the case of reclaimed tailings footprint sites in the East Rand and West Rand of Gauteng in South Africa, where informal settlements have been established as land has become available post-mining (Limpitlaw & Briel, 2014), and this land is however, not suitable for housing developments due to the risks posed by residual tailings material.

Mining activities usually come with different types of metals in potentially toxic quantities to a mine site, and to soils and waters far off; and the contamination by heavy metals or radiation in unreclaimed or improperly reclaimed sites can substantially limit post-mining land use potentials (Venkateswarlu et al. 2016; Pereira et al. 2014).

Compared to metal mines, quarries (mines which produce building materials and dimensional stone) tend to have more versatile post-mining options because they usually have less hazardous wastes and are located closer to densely populated areas (Lintukangas et al. 2012; Stefano & Paolo 2016; Slingerland & Wilson 2015). There is limited knowledge regarding the environmental condition of many closed mine sites. Detailed assessment of the further reclamation needs would be necessary in order to understand the potential risks related to various kinds of post-mining land use (Slingerland & Wilson 2015; Sonja 2017).

Post-mining activities resulting in breaking up and dusting of the ground contaminated by heavy metals can pose health hazards. For instance, some locals in various mining regions globally that have used the unremediated tailings of old gold-copper mines for dirt track biking, notwithstanding environmental regulatory authorities prohibiting this activity due to arsenic and copper contamination of the area (Parviainen, 2012). It was also recommended that the Finnish Defence Forces stop using arsenic contaminated tailings of a closed copper-wolfram mine as a test field for explosives in order to prevent dusting and the transport of particles to the surrounding areas (Parviainen, 2012).

Surface and/or groundwater contamination has been observed in the vicinity of many post-mining areas in Finland (Sonja 2017). For instance, the tailings of a closed copper-wolfram mine have been noted to be a major source of arsenic leaching into the surface and ground water. Similarly, Parviainen (2013) suggests that swimming in Parosjärvi lake, which is in the immediate vicinity of the mine, should be prohibited, and groundwater wells for household use in the nearby area should be regularly monitored for potential arsenic contamination. Sand, gravel, and rock have been extracted from the old mining sites (tailings, waste rock) for construction purposes (Sonja, 2017). However, more attention should be paid to the suitability of these materials – particularly for residential and yard construction. For example, local heavy metal contamination of soils in residential regions outside the Outokumpu mining sites has probably resulted from mining waste utilised in house foundations (Sonja, 2017).

Uranium mining poses challenges for remediation and future land use (Pereira et al. 2014). For example, the case of a small uranium mine, in a remote forest landscape, which had remained abandoned for nearly three decades (Colpaert, 2006). Despite remediation measures, which included the planting of a pine forest, Tuovinen et al. (2016) indicate that leaching and accumulation of radium from the waste-rock pile and possibly tailings are still ongoing.

In the case of underground mining, land subsidence is an important hazard that may cause extensive damage and threaten social and economic activities (Zhao & Tang, 2015). For instance, a sinkhole of approximately 600 m^2 opened in the vicinity of residential buildings in a copper mining area closed in 1960. Land subsidence and sinkhole collapses due occur long after the mineral extraction has ended (Bell et al. 2000) therefore these processes must be considered, particularly in abandoned post-mining areas or sites where post-closure monitoring is no longer carried out (Sonja, 2017).

2.6 SUMMARY

The purpose of this study is to, *inter alia*, understand how mine closure planning contributes to EIA, and can be implemented as part of the EIA, focusing on some of the main concerns and prospects based on experience in the South African context. It is aimed at environmental impact assessment practitioners and researchers that are involved in improving the effectiveness of legislative processes that are focused on providing excellent environmental and socio-economic gains from mining development initiatives.

Effective rehabilitation results rely on the scientific quality and amount of environmental information gathered at the location (Glenn et al. 2014). Both the progress of the physical aspects of rehabilitation, such as soil stripping, land-forming, and soil substitute during the operational cycle and advancement in restoring the desired final landscape functions and services need to be carefully monitored (CoM, 2007). The desire of the mine houses to make decisions regarding the functionality of the post-mining landscape has been illustrated in the rehabilitation intentions identified in this chapter, as well as their related significance to the post-mining context for land use planning, SDGs, NDP, AMV, contrasting possible post-mining land use options, and land capacity, as intertwined with existing DAFF land use capability classes.

This is particularly the case in the mining sector, which needs to develop environmental and socio-economic management policies for post-mining land use that are strongly aligned with statutory regulation (Doley et al. 2012). It is my desire that mining policies will be properly translated into strategies for mine closure planning, which currently is not occurring in any significant way. Whereas land capability relates to the prospects of the land, based on its ecological qualities, this study considers land capacity as essential to determine whether a predefined post-mining land use plan can be accomplished through regulatory instruments such as environmental impact assessment reports.

CHAPTER 3: STUDY METHODOLOGY

3.1 INTRODUCTION

The study methodology for post-mining land use sustainability assessment presented in this chapter is aimed at providing procedures specific to addressing the objectives of this dissertation. The methodology proffered would assist in understanding EIA reports and land use related decisions that need to be made to improve post-mining land use planning. Traditionally, mine closure has been environmentally ineffective, creating lasting negative consequences. This situation is exacerbated by the fact that South Africa has in excess of five thousand ownerless and derelict mines (DME 2007).

3.2 METHODOLOGY

The research method used in this dissertation is case study-based. A case study primarily falls within the qualitative research paradigm (Saunders, Lewis, & Thornhill, 2000) and can also be applied within the context of a quantitative research framework (Watkins, 2012; Kirk & Miller, 1986; Golafshani, 2003). A case study is very specific and not generalised. Furthermore, a case study research aims not only to explore certain phenomena, but to understand and contextualise them (Collis & Hussey, 2009). It is an all-encompassing research method that is typically utilised when contextual conditions are subject of research (Watkins, 2012; Saunders et al. 2000). An introduction is provided for the method used in the study with emphasis on its applicability to post-mining land use, which entails detailed review of, *inter alia*, how mining EIA processes are conducted in South Africa.

The study utilised a two-step methodology. The first step involved assessing the selected (three) case study. This initial assessment was done by evaluating the legal framework, institutional, and processes of the EIA reports that support post-mining land use. Secondly, analytic criteria were utilised in the comparative analysis of the case study. The analytic criteria utilised are relied on those proposed by Leu, et al (1997); Balsam & Wood (2002); and Wood (2003). These authors classified analytic criteria under two categories: systemic measures and foundation measures.

The systemic measures are further divided into three categories, namely legal framework, administration framework, and the EIA processes. The foundation measures, on the other hand, access the existence of general guidelines issued by the national authority responsible for EIA.

The study is primarily focused on qualitative analysis of the EIA requirements and its practical application to sustainable mining end land use. It considers legal framework; institutional context and processes of each EIA report, where after detailed comparison of the EIA attributes is expanded to examine the:

- legislative and administrative processes for the EIA reports;
- specific components of EIA report, such as I&APs, public participation processes, and input; as well as EIA report review; and
- measures taken in environmental management plans (EMP), if any; for the effective implementation of EIA reports with regard to post-mining land use.

The first two points of these attributes are part of systemic measures, while the last attribute relates to the foundation measures. To guide the development of a mining-related land use planning approach in the context of South African mining industry, *inter alia*, review of relevant literature partnering with the industry was used to identify existing approaches to post-mining land use. The results and analysis thereof are presented in Chapter 4.

3.2.1 SYNTHESIS AND DISCUSSIONS OF EIA PERFORMANCE FOR POST-MINING LAND USE PLANNING

The two-way methodology used in this study provided a good foundation that interrogated, inter alia, the EIA regulatory processes with a strong focus on environmental compliance. However, my core interest in this study was to establish whether EIA reports contributed to post-mining land use planning, including providing grounds for a sustainable post-mining land-use, including stakeholders' engagement processes. Hence, I further dissected the three EIA reports (case-by-case) in the next chapter (synthesis and discussion) with specific focus on the following:

- A synthesis and discussion of the post-mining impact identified on the affected land (pre-mining), and whether there are any plans proposed in the EIA reports for post-mining land use and, if any, what they would be.

- A synthesis and discussion on the I&APs' participatory process, looking at how it was conducted, who the stakeholders were, what their input was, whether there was any resistance by stakeholders, whether there were any disagreements among the stakeholders (and what the concerns were). I then checked whether this input was considered in the EIA reports, as well as the language used during the consultation processes and the various notices. I further analysed and presented the basis for competent authority approval.
- A synthesis and discussion on the specialist study to understand what type of specialist studies were conducted in the various case studies and whether any references or recommendations regarding post-mining land use were made by the various specialists.

3.3 CASE STUDIES

In this study I evaluated three mining EIA reports (EIA on the extension of mining operations at the Vlakvarkfontein Coal Mine; EIA on consolidation of high-extraction mining impact in the Trichardtsfontein mine; and EIA on rail loop, road diversion, and pipeline project associated with Temo Coal) regarding the extent of post-mine land use consideration in the EIA process, as well as the context; inter alia, whether the contributions of I&APs were considered in the environmental impact assessment reports, and to what extent such input contributed to the post-mining land use plan, including how the socio-economic impact of mine closures on host communities was evaluated.

These three case studies are the very few mining EIA reports in the public domain that I could access. I was interested in these case studies because of the apparent lack of post-mining land use planning in all three EIAs, especially as the affected land was originally agricultural land. For instance, the Vlakvarkfontein Coal Mine activities would entail the construction of access roads and haul roads where the road is wider than 8 m; extension of existing farm roads or haul roads by more than 1 km; as well as physical modification of vacant agricultural land for mining purposes, and the anthropogenically impacted area is more than 20 hectares. Similarly, the Temo coal road diversion involved the entire extent of the rail loop of 22,25 km in length with a 25,0 m wide servitude, resulting in a total footprint of 55,6 ha.

3.3.1 Vlakvarkfontein Coal Mine

Background

Vlakvarkfontein Coal Mine produced its first coal on 27 May 2010 (EIMS, 2017). Operations started approximately 50-100 m east of the old underground workings with a north-south box-cut, and advanced to the east. The current infrastructure map is shown in Appendix 2. This portion or section of the mine was planned and indicated in the original mining right application. Very few resources are left in this section of the mine and it will be fully depleted in 2019 (See Appendix 3: Life of mine production schedule).

The more challenging resources in the old underground mine and a little to the west were only explored and decided to be proposed for mining in 2016 while the new opencast operation would be initiated by the stripping of topsoil to expose the overburden of the proposed box-cut. The topsoil, and subsoil, would be transported to a designated area and act as a buffer between the host community and the mine (EIMS, 2017). The coal mine is an operating opencast coal mine practising a drill and blast, load and haul mining method, selling the select seams on a RAW crush and screen basis to Eskom at a rate of 100-140 ktpm to be used in some of their power stations.

This project's activities were triggered under GNR.984 , hence a full EIA process was required (EIMS, 2017). EIA approval was sought for the following activities (EIMS, 2017):

- Construction of pollution control dams and dirty water storage reservoirs with a combined capacity of 50 000 m^3 or more. The dam wall height falls below 5 m;
- Construction of access roads and haul roads where the road is wider than 8 m;
- Extension of existing farm roads or haul roads by more than 1 km;
- Physical modification of 20 hectares unused agricultural land for mining;
- Construction of a fuel storage facility; and
- Construction of clean and dirty water canals with a width of more than 36 cm in and around the mining areas.

According to EIMS (2017), the extension of the proposed opencast mining operations at Vlakvarkfontein Coal Mine, is necessary because:

- It allows for continued mining operations which favourably contributes to both local and regional economies.
- The current mine reserves will be depleted by 2019 and would lead to job losses and negatively impact on the economy of the region.
- Vlakvarkfontein Coal Mine extension will further extend the profitability and life of the Vlakvarkfontein mining operation by more years, which will guaranty job security for the current workers.
- A major part of the coal reserve must be sterilised should the mining not take place. This also means that the additional economic activity, skills development, and no creation of jobs opportunities, the coal reserves will also not be unutilised.
- Mining activities proposed fits in with the developments and land use of the surrounding area, which is mining. (See Appendix 4: Topographical locality map)
- Should Ntshovelo (Pty) not embark on the mining operation proposed, it does not mean that coal mining will not proceed, because application in terms of the MPRDA, Act 28 of 2002 can be filed by another company.
- Until government declares the mining area “off limits” or demand for coal reduced, there will be relentless effort by mining houses to continue mining coal reserves.

  In summary, the Vlakvarkfontein mine extension proposed, will allow applicant to continue the production of a secure, steady coal supply, for use by Eskom, for another six years.

3.3.2 THE CONSOLIDATION OF HIGH-EXTRACTION MINING IMPACTS IN THE TRICHARDTSFONTEIN AND VAALKOP MINING RIGHT AREAS

Background

Sasol Mining (Pty) Ltd (Sasol Mining) holds mining rights for the Twistdraai Colliery: Thubelisha Shaft (TCTS) and the Vaalkop mining area, which were both incorporated into the regional Sasol mining right (Digby Wells, 2017). The project local setting (Appendix 5) which includes the Trichardtsfontein Mine, Vaalkop, and TCTS are located between the town of Trichardt and Bethal in Mpumalanga province. The town of Evander is 17 km to the west and Secunda is 10 km southwest of the Trichardtsfontein and TCTS mining area. Vaalkop is located 5 km southeast of Bethal and 17 km southwest of Trichardt. The consolidation project area and coal reserve are located within the Bethal Magisterial District, the Gert Sibande District Municipality (GSDM), and the Govan Mbeki Local Municipality (GMLM).

A high-extraction method of mining using bord-and-pillar mining with pillar extraction is used at the TCTS and is proposed to be utilised at the Trichardtsfontein and Vaalkop mines. In mechanised bord-and-pillar mining process, extraction is achieved by developing severe roadways (bords) in the coal seam connected by the splits (cut-throughs) to form pillars (Digby Wells, 2017). In high-extraction mining, all the pillars are extracted to allow the roof to collapse in a controlled manner (called stooping), initially mining will occur to the east and west and move towards the north and south (Digby Wells, 2017).

The mining method which is currently being used at TCTS includes bord-and-pillar mining as well as high-extraction mining in some areas. This mining method has also been proposed for Vaalkop (Digby Wells, 2017).

- The mining method proposed for the extraction of coal at Trichardtsfontein only included the traditional bord-and-pillar method, with the utilisation of continuous miners feeding shuttle cars. Twistdraai Thubelisha is now proposing (Appendix 6) that in addition to the bord-and-pillar mining process, a high-extraction-mining will be undertaken at the Trichardtsfontein Mine.

- It is proposed that Twistdraai Thubelisha will construct two additional ventilation shafts (Appendix 7: Land use footprint) at TCTS (east ventilation shaft) and two ventilation shafts at Trichardtsfontein south ventilation shaft.

All these activities further triggered the new EIA Regulations, 2014 (as amended) promulgated in terms of the NEMA Act No. 107 of 1998, for the construction and operation of the ventilation shafts. Due to the depth of the resource (30 m to 215 m), underground mining is used to access the ore body (Digby Wells, 2017).

3.3.3 RAIL LOOP, ROAD DIVERSION, AND PIPELINE PROJECT ASSOCIATED WITH THE TEMO COAL MINE, LIMPOPO PROVINCE

Background

This project entails the construction and operation of road diversion, a rail loop, and a bulk water transfer pipeline. The infrastructure will be associated with the operation of the existing Temo Coal mining right (Appendix 8: The mining right local setting) environmental authorisation (Digby Wells, 2019). The current D175 road runs along the western corner of the Temo Mine mining right area, which transects the southwestern corner of the approved open-pit area. To facilitate continued mining, Temo Coal is proposing:

- The D175 be diverted around the mining area. The proposed rail loop is intended to enable Temo Mine to transport coal to domestic markets as well as export-grade coal transportation of product to Richards Bay Coal Terminal (RBCT).
- The proposed rail loop be joined with the Boikarabelo rail link located south of the Temo Mine mining right area, to facilitate haulage of coal to the domestic markets, and move export-grade coal product to the Richards Bay Coal Terminal (RBCT), and
- Lastly, to construct and operate an underground bulk water transfer pipeline between Temo Mine and the Lephalale Wastewater Treatment Works (WWTW). The purpose of the pipeline is to provide process water to the mine.

The approved open-pit area has a road, the D175, which transects the southwestern corner of the future pit area and continues to exit the mining right boundary near its northwestern corner (Digby Wells, 2019).

To facilitate continued mining at the Temo Coal Mine, Temo then proposes that the D175 be diverted around the mining area. The length of the road diversion is approximately 2,8 km with a 30,0 m servitude, resulting in a total footprint of 8,4 ha (Digby Wells, 2019).

The proposed diversion will diverge from the existing route at the western mine boundary and will be diverted just inside the eastern farm boundary of the farm Draai Om 244 LQ. Where the southern boundary of the farm Nazarov 685 LQ meets the eastern boundary of farm Draai Om 244 LQ, the diversion will head in a northeasterly direction. The total extent of the rail loop is 22,25 km in length with 25,0 m wide servitude, resulting in a total footprint of 55,6 ha. The loop itself will be on the farm Duikerpan 249 LQ and the railway line will then run to the west of the loop along the southern boundary of the mine, within the farm Verloren Valei 246 LQ towards the D175 road.

Land use alternatives were considered for properties associated with the proposed ancillary infrastructure (Digby Wells, 2019). The rail loop is planned on the farm Duikerpan 249 LQ and its current land use is agricultural. Temo is in the process of altering the land use to industrial as this property is in Temo Mine’s right area. The current land use in Draai Om 224 LQ, which is associated with the road diversion is mining and therefore the section of the road diversion, will be constructed on this farm (Digby Wells, 2019).

3.4 RESEARCH ETHICS

Ethics in research is to protect the dignity of research subject, and the publication of information obtained in research activities (Fouka & Mantzorou, 2011). It also referred to as the appropriateness of behaviour in relation to the rights of those that become the subject of the research or are affected by it (Saunders, Lewis, & Thornhill, 2000).

In view of the above background and in compliance with the general requirements of research at the University of Cape Town, application for ethics clearance was submitted. This study is a structured qualitative review of the EIA documents only, it did not involve obtaining evidence from human subjects; consequently, the application for ethics clearance was approved and it is herein attached as an appendix.

CHAPTER 4: RESULTS AND ANALYSIS

4.1 INTRODUCTION

As discussed in chapter 3, this study is based on data structured analysis of three mining EIA reports in South Africa. The three mining EIA reports are those regarding:

- the extension of mining operations at the Vlakvarkfontein Coal Mine;
- the consolidation of high-extraction mining impacts at Trichardtsfontein; and
- the rail loop, road diversion, and pipeline project associated with Temo Coal

These EIA reports are used as case studies to provide an insight into the mining EIA process in South Africa and its relevance to post-mining land use.

Thus, the chapter provides an analysis and results of the reviewed EIAs, including post-mining land use literature relevant to this dissertation. Although most post-mining land use related literature seems to focus on rural development planning, this study is concerned with the mining environment and the contribution of EIA reports to achieving a sustainable post-mining land use that addresses environmental and socio-economic impacts of mine closure on local communities.

Appendix 9 shows the comparative analysis of the EIA reports, while the systemic measures of the various EIA reports are presented in Appendix 10. It provides detailed analysis of the legal framework, administrative framework, and the EIA processes. This is followed by the foundation measures that highlighted the general guidelines issued by the national authority responsible for the EIA reports.

4.2 CASE DISCUSSIONS

The foundation measure of the EIA reports against foundation evaluation criteria (applicable EIA guideline) shows that the use of environmental impact assessment guidelines is widely encouraged and followed in the EIAs under review. In South Africa, the EAP manages the application for environmental authorisation on behalf of the proponent and determines which process to follow. This can be either basic assessment, scoping and EIA, or an exemption request.

In general, activities identified in Listing Note 1 No. R386 are subject to a basic assessment and those in Listing Note 2 No. R387 are subject to scoping and an EIA. However, where the competent authority cannot reach a decision based on a basic assessment, it can order the proponent to subject the activity to scoping and EIA. Similarly, a proponent can also obtain written authorisation from the competent authority to subject an activity listed in Listing Note 1 No. R386 to scoping and EIA.

Furthermore, the three EIA reports have each conformed to the applicable legal framework for conducting an EIA. This EIA legal framework applies to new projects and expansion and renovation of existing projects, as well as procedural specifications for deadlines. These deadlines are clearly defined at various stages in the EIA process, for instance, in screening, scoping review, and the final assessment. All the EIA reports reviewed in this study required public participation before or during the review stage, and public consultation was mandatory during the scoping process.

4.2.1 VLAKVARKFONTEIN COAL MINE EXTENSION, ASSOCIATED INFRASTRUCTURE, AND AMENDMENTS TO EXISTING LICENCE CONDITIONS

Land use

The project area is approximately 103 hectares in size with mining and infrastructure occupying 83, 2 hectares (EIMS, 2018). The wetland areas are 0,18 ha in size and the veld (grassland) accounts for the remaining 19,1 ha. Cultivation exists around the mining area and a residential settlement (known as Arbor Village) exists to the north and northwest of the proposed mining area. Evidence of overgrazing and unrehabilitated mining is found within the greater study area (EIMS, 2018).

Semi-rehabilitated and unrehabilitated mining areas, artisanal mining, and exposure of these areas to erosion, have contributed to soil erosion, contamination of soils, decanting of mine affected water and wattle tree invasion (EIMS, 2018).

Post-mining impact identified

The concern about post-mining impact was the groundwater flow directions, contamination plumes that potentially spread towards the northwest of the expansion area pit, and to the south (EIMS, 2018). Furthermore, the concern was also about smaller plumes that will extend north of the Vlakvarkfontein current pit and southwest of Wescoal.

Due to historical opencast or underground mining and acid mine drainage (AMD) decant (pH of 2.8 to 3.2; SO_4 of 1000 mg/L to 1500 mg/L), the groundwater plume to the south will develop into an aquifer which has already been contaminated. Decant to surface has historically drained overland towards the Klipspruit (also known as the Leeuwfonteinspruit) and is considered the most likely situation during the post-mining (EIMS, 2018). The area within and surrounding the Vlakvarkfontein Coal Mine is characterised by intensive agricultural (maize production and grazing), mining (semi-rehabilitated mine), industrial (Spoornet railway and Arbor siding) and residential (Arbor informal settlement) uses. Through the intensity of the above-mentioned uses, the wildlife habitats in the area have been severely affected (EIMS, 2018).

The project area lies within the grassland biome, one of nine biomes in South Africa. This is the second largest of the South African biomes, covering approximately 30% of the country. The area is being used predominantly for agriculture and mining (EIMS, 2018).

Stakeholders participation process

A focus group meeting was held on 27 July 2017 with the community leaders from Arbor, representatives from Mbuyelo, and the study specialists (EIMS, 2018). Six site notices (in English, Afrikaans and isiZulu) were put up, along and within the perimeter of the proposed project area on 4 August 2017 (EIMS, 2018) and the I&APs were provided a period from 7 August 2017 to 11 September 2017, to register as I&APs for the proposed project (EIMS, 2018).

The purpose of the meeting was to explain the proposed project. The public participation process (PPP) commenced on 7 August 2017 with a 33-day initial notification and call to register for a period, ending 11 September 2017. The scoping report was made available for public review and comment for a period of 32 days from 19 October to 20 November 2017 (EIMS, 2018).

Furthermore, a one-on-one consultation with the host community was undertaken whereby an EAP visited each household in Arbor and its surroundings. The one-on-one consultation involved presenting the documents related to the project including explanation of the project and the environmental impact assessment. These consultations were carryout in the language of choice of the community member (mostly in isiZulu) (EIMS, 2018). All comments received were recorded and included in the issues/comments, and responses section of the EIA report (EIMS, 2018). A summary of issues raised during consultation process is presented in Appendix 11.

Notification regarding availability of the scoping, and EIA report for public review was provided in the following manner: Registered letters with details on where the scoping report is available from, and public review comment period, were distributed to registered I&APs, including key stakeholders and surrounding landowners; facsimile notifications with information similar to those in the registered letter mentioned, were also distributed to all registered I&APs; and email notifications with letter attachment that contained information as described, were sent to the registered I&APs. The scoping report was also made available for public review for a period of 31 days from 19 October 2017 to 20 November 2017, and the EIA report was also available for a 30-day review period from 7 March to 10 April 2018 (EIMS, 2018).

Socio-economic demographics

The population density in the local area where Vlakvarkfontein Coal Mine is located is limited to residents of the Arbor settlement, as well as farmers and their workers (EIMS, 2018). The area of influence includes the Nkangala District Municipality, and the greater Victor Khanye Local Municipality as well as the Emalahleni Local Municipality. The most affected stakeholders are the adjacent commercial farmers and more directly, the Arbor community. About 300 households occupy this land. The Arbor community is a poor community with high levels of illiteracy (EIMS, 2018).

Specialist studies

Specialist studies were done to address the impact on biodiversity, groundwater, heritage, palaeontological heritage, aquatics and wetlands, blast and vibration, air quality and health, noise, social, and closure costing. Furthermore, soil impact assessment was carried-out, and three main soil forms were identified, namely the Clovelly, Oakleaf, and Katspruit soil forms (EIMS, 2018). The Clovelly soil form was classified as Class III. The Katspruit soil form was classified as Class V, due to signs of wetness within the first 200 mm. The Oakleaf soil form was classified as land capability class IV. The specialist studies involved identification and assessment of the environmental impacts that may result from the proposed project, and the recommendations proposed were mitigation/control or optimisation measures that will reduce potential negative impact or enhance the potential benefits.

Motivation for granting the EIA

The EIA report (EIMS, 2018) indicated that the extension of the proposed opencast mining operations at Vlakvarkfontein Coal Mine allow the mine to continue its favourable contribution to both local and regional economies. The current mine reserves will be depleted by 2019, and consequently lead to job losses and economy in the region. Therefore, Vlakvarkfontein Coal Mine extension seeks to extend profitability, and the life of Vlakvarkfontein coal operation by an additional few years in order to guarantee the job security for current workers, and substantial part of the coal reserve must be sterilised should mining not proceed in the area. EIMS, (2018) is of the view that if the project were not to proceed, the extra economic activities, skills development, and there will be no creation of jobs opportunities, the coal reserves will also not be unutilised.

In addition, the report suggested that if Ntshovelo (the mining company) not embark on the mining operation proposed, it does not mean that coal mining will not proceed, because application in terms of the MPRDA, Act 28 of 2002 can be filed by another company. Until government declares the mining area not suitable for mining or demand for coal reduced, there will be relentless effort by mining houses to continue mining coal reserves. It also advised that the proposed Vlakvarkfontein mine extension will allow applicant to continue the production of a secure, steady coal supply, for use by Eskom, for another six years (EIMS, 2018).

4.2.2. REHABILITATION, DECOMMISSIONING AND MINE CLOSURE PLAN FOR THE THUBELISHA, TRICHARDTSFONTEIN, AND VAALKOP MINING RIGHT AREAS

Land use

The most dominant land uses are cultivated areas (maize and soya beans), grassland and low shrubland (grazing), mine areas, urban areas, and water bodies. The land use is classified as follows: Cultivated areas (8 059,82 ha); grassland and low shrubland (12 388, 60 ha); thicket/dense bush (206,14 ha); mine areas (229,57 ha); urban areas (62,43 ha); and water bodies (1 615,96 ha) (Digby Wells, 2017). Commercial agricultural is the most dominant land use in the district while the petrochemical industry is the main contributor to municipal output.

Mining, particularly coal mining, is also an important land use, with Secunda being the most active business area in the municipality. The land is, to a lesser extent, used to graze livestock; particularly cattle, and approximately 98,10 ha is considered to have arable land potential, 3 620,35 ha is grazing land, 4 176,99 ha is wilderness and the project area is characterised by large areas of wetlands; totalling 5 278 ha (Digby Wells, 2017).

These include three major types of wetlands, namely, channelled valley bottom systems, hillslope seeps, and floodplains. All three identified wetland types function differently and are mapped as National Freshwater Ecosystem Priority Areas (NFEPA) and thus recognised for the role they play in supporting and providing services to the surrounding area. Of interest is that these wetlands were also identified as Critical Biodiversity Areas (CBAs) and Ecological Support Areas (ESA).

The land suitable for sustaining arable crop production will require the utilisation of the deeper (>750 mm) well-drained, red (Hutton) and yellow-brown (Clovelly and Griffin) soils that occur on the mid-slope and upper mid-slope positions. However, the deeper hydromorphic soil (Avalon and Pinedene) forms are capable of sustaining crop production. The areas that are classified as grazing land are generally restricted to the shallower and transitional zone. The majority of the Vaalkop study area (4 026,8 ha and 46%) had undergone transformation due to cultivation of maize and the presence of pastures with alien vegetation (Digby Wells 2017).

Digby Wells, 2017 indicated that livestock was observed throughout most of the site and evidence of overgrazing was recorded in grassland areas; showing a dominance of increaser species and some erosion. There are two major floodplain systems which drain into one another to the west of project site, as well as large channelled valley bottom system which drains into the northern floodplain system (Digby Wells, 2017), and the remainder of the area is characterised by extensive hillslope seeps that drain into the floodplains and valley bottom wetlands.

Land capability class

Land capability within the consolidation project site was determined by assessing combination of soil, terrain and climate features. The dominant land capability classes presented in report was Class II (Intensive cultivation, 5 571,96 ha), Class III (Moderate cultivation, 1 161,50 ha) and Class IV (Light cultivation/intensive grazing, 16 583,34 ha) (Digby Well, 2017).

Post-mining impact identified

The final land use plan (LUP) is essentially the end land use to which Sasol would like to return the land affected by mining activities. The closure objectives set as part of mine closure planning process ensures that the final LUP is achieved and that the area is sustainable in the long-term from an environmental and social point of view. Due to the fact that mining is underground, it was noted that subsidence will impact land use when there is a collapse.

Ongoing monitoring and modelling were undertaken to predict whether subsidence would occur, and the risk associated with such event, and to rehabilitate the areas to the pre-mining land use. It is also expected that the current land use for the study area will continue during the operational phase and well into the post-closure phase as the mining method is underground mining, which allows farmers to utilise the surface during the LoM. However, poor water quality emanating (decanting) post-closure, including the potential formation of AMD, is a concern.

Stakeholders participation process

Stakeholders identified as affected by or interested in the consolidation project were grouped into the following broad categories: Government: national, provincial, district, and local authorities; Land occupiers: Directly-affected and adjacent; Communities: directly-affected and adjacent communities; Non-governmental organisations (NGOs): environmental organisations, community-based organisations; Landowners: directly-affected and adjacent landowners; and Business: small medium enterprises, mines, and formal business organisations (Digby Wells, 2017).

The premise of activities was to ensure that the various legislative requirements for PPP were met and that a single, integrated process was followed. This ensured that stakeholders were presented with a common view of the full consolidation project and amendment information. PPP activities during the amendment application phase revolved around I&APs providing comments on specialist study findings, recommendations, and proposed mitigation measures. A stakeholder database was developed which included I&APs from various sectors of society including directly-affected and adjacent landowners, in and around the consolidation project site. A background information letter (BIL), and an announcement letter, with a registration and comment form was emailed, and mailed to the stakeholders on 29 January 2018.

Socio-economic demographics

The project area consists of approximately 9 000 households at an average occupancy rate of 3,6 persons per household. The project is located in Govan Mbeki Local Municipality (GMLM) within Gert Sibande District (GSDM). The population of GSDM and GMLM is about 1 044, 000 and 295 000 respectively (Stats SA, 2012; Digby Wells, 2017). The ethnicity of the district and local municipal areas is mainly Black African (89% and 81% respectively). The dominant language in both areas is isiZulu; with the primary study area reflecting these trends. With regard to age, the youth (individuals between the ages of 14 and 35) comprise the largest age group in the district (38%) and local municipality (39%) (Stats SA, 2012; Digby Wells, 2017). Within the GSDM, the GMLM has the highest level of functionally literate people at 74% of the population older than 20 years. According to Digby Wells (2017) on average, close to a third (30,9%) of the primary study area's adult population have completed Grade 12.

Specialist study

The specialist studies undertaken by EAP to assess the impact of the consolidation project with specific focus on the Vaalkop mining right area were: air quality specialist study; noise specialist study; heritage specialist study soils, land use and land capability specialist study; fauna and flora specialist study; wetlands specialist study; surface water specialist study; aquatic ecology study; groundwater study; and rehabilitation and closure study (Digby Wells, 2017).

Motivation for granting the EIA

Sasol Mining has for many years provided coal to its petrochemical operations. The coal is then sold to the domestic markets as well as for export purposes. TCTS has been operating as an underground coal mine since 2010. It is proposed that Trichardtsfontein will begin mining once authorisation has been granted to include the high-extraction method of mining as well as the construction and operation of the ventilation shafts. Additional coal will be extracted from the Vaalkop operation once mining commences in 2029.

Sasol's annual contribution to the South African GDP amounts to approximately R40 billion of which R22 billion is a direct contribution. Sasol produces approximately 34% of the country's liquid fuel requirements and at least 20% of the country's saleable coal (Digby Wells, 2017). Sasol Mining supplies coal to Secunda Synfuels Operations (SSO) where the colas is processed to produce petrol, diesel, chemicals, and chemical by-products. Additionally, a certain amount of coal is exported to European and Asian markets. Sasol Mining contributes substantially to the creation of employment and development of various social initiatives to assist and provide opportunities to historically disadvantaged South Africans (HDSAs).

It is not predicted that any new job opportunities will be created by the various mines, however, the mine will have a cumulative impact on the social environment as various mines within Mpumalanga are proposed to reach life of mine. Through the acquisition of the various reserves and commencement of the mining operation it would be possible to extend the life of the Secunda Synfuels Plant to 2050. This includes enhancing the capability to continue supplying coal for export, thus ensuring job security of the employees at the TCTS operation, as well as continued supply of coal to produce transportation fuels and chemicals. It was envisaged that consolidation of the project will have negative impact on physical environment but with positive effect on social environment as mining continues to develop from TCTS to Trichardtsfontein and Vaalkop.

It was predicted that mining would result in an estimated gross domestic product (GDP) contribution to local economy in turn of R500 million (based on construction wages including an estimated 50% of construction capital costs at 2008 prices) and employment for 500 workers during construction. During the operational period of 20 years this figure will be approximately R419 million per annum and 1 221 jobs will be created. However, the report cautioned the competent authority to take note of the potential negative impacts will have for mining should authorisation not be granted (Digby Wells, 2017).

4.2.3. RAIL LOOP, ROAD DIVERSION, AND PROJECT ASSOCIATED WITH THE TEMO COAL MINE, LIMPOPO PROVINCE

Land use

Grassland for grazing is the main land use in the area. The land is confined almost exclusively to low intensity livestock grazing and game farming. It is noted that the pipeline trajectory cuts across land used for urban development, namely the towns of Lephalale, Onverwacht, and Steenbokpan. The proposed project is located approximately 60 kilometres from Lephalale in Limpopo Province (Digby Wells, 2019).

The project area is located within Limpopo Sweet Bushveld and the landscape features, characteristic of this vegetation type, include plains traversed by several tributaries of the Limpopo River. The area is located within the Limpopo water management area (WMA1), which forms part of Limpopo river basin, which is a regarded as a dry catchment with no significant dams (with the exception of the Mokolo Dam) and a low growth potential for land use development.

49 watercourses (inclusive of the Sandloop River and two artificial systems) were identified in the vicinity of the project area, which are classified predominantly as depression (pan) wetlands with present ecological status (PES) scores that range from Category A (Natural) to Category D modified in most part. In the report, land capability was determined through the combined assessment of soil, terrain and climate features. The land classes were identified, based on soil forms, texture, and fertility. The low rainfall of the area restricts the utilisation potential of study area to low-intensity grazing, and wildlife conservation.

The land capability class was identified as Class VI. Land in Class VI has limitations that make land unsuited for cultivation and its use is classified largely as pasture, wildlife, and range. Limitations that cannot be corrected include a severe erosion hazard and low water holding capacity (Digby Wells, 2019).

Stakeholders Participation Process

A PPP was initiated during the scoping phase, and it is core to investigation of environmental and social impacts, because it is important that stakeholders that may be affected by project are given an opportunity to identify concerns and to ensure that local knowledge, needs, and values are understood and considered as part of impact assessment process. The draft EIA and EMPr were submitted to the public for their input and comments for a period of 30 days. Commenting period was from 8 April 2019 to 10 May 2019. Stakeholders were grouped into various categories such as land owners/occupiers, communities, relevant government organisations, non-governmental organisations (NGOs), and business enterprises.

The EAP indicated that draft EIA and EMPr were available on their website for review and comments. Electronic copies (CDs) were available from the Public Participation Office, while hard copy of site notices were put up at the proposed project site, as well as at Lesedi Village, Steenbokpan; municipal offices, and Lephalale Local Municipality Public Library on 25 October 2018. These notices were in English. A public meeting was held on Wednesday, 14 November 2018 from 10:00 to 12:00. The final notification for EIA and EMPr report availability was emailed, and sent via SMS to stakeholders on 17 May 2019.

Socio-economic demographics

Limpopo is divided into five district municipalities, which include 22 local municipalities. Of these, Waterberg District Municipality (WDM) is the largest district municipality, comprising 35,71% of the province (Wazimap, 2017; Digby Wells, 2019).

Table 4.4 Waterberg District Municipality wards in the study area.

Primary study area	**Secondary study area**		
Ward 3	Ward 11	Waterberg District Municipality (WDM)	Limpopo province
Ward 4			
Ward 13			

Adapted from Digby Wells, (2019).

WDM is divided into five local municipalities, Bela-Bela; Lephalale; Modimolle-Mookgophong; Mogalakwena; and Thabazimbi.

Lephalale Local Municipality (LLM) is the largest of the local municipalities within the WDM, and the project area is located within Wards in the primary study area.

Table 4.5. Demographics of the study area

Statistic	Secondary study area			Primary study area		
	Limpopo	WDM	LLM	Ward 3	Ward 4	Ward 13
Population	5 404 868	679 336	118 865	10 836	5 428	6 054
Size (km^2)	125 806,1	45 315,6	13 826,1	4509,0	7,8	31,4
Population density (people/km^2)	43	15	9	2	696	193
Number of household	1 447 658	191 214	33 599	3 762	1 832	1 976
Average household size	3,73	3,55	3,54	2,88	2,96	3,06

Adapted from Digby Wells, (2019)

Table 4.6. Languages in the study area

Language	Limpopo	WDM	LLM	Ward 3	Ward 4	Ward 13
Common language	Sepedi	Sepedi	Sepedi	Afrikaans	Afrikaans	N/A
Second-most common	Xitsonga	Setswana	Setswana	Setswana	Sepedi	Afrikaans
Third-most common	Tshivenda	Xitsonga	Afrikaans	Sepedi	English	Sepedi
Least common	Sign language	Sign language	Sign language	Sign language	Sign language	Sign language

Adapted from Digby Wells, (2019)

Specialist study

The purpose of understanding the environmental baseline conditions relates to the potential project impact on the existing environment. The specialist study considers existing environmental aspects that may affect a proposed development in terms of design, location, technology, and layout. The assessment that were undertaken during the EIA phase for the proposed project are the following: soil, land use and land capability; flora and fauna; wetland and aquatic ecology; surface water; groundwater;

air quality; noise; heritage assessment; socio-economic assessment; and rehabilitation and closure liability assessment.

Motivation for granting the EIA

The EIA considered potential negative and positive impacts that are associated with proposed project. For all the potential impacts, mitigation, and management measures have been proposed which, when correctly implemented, are likely to minimise impacts to minor or negligible significance. The key potential positive implications associated with the proposed project are temporary employment opportunities and opportunities for local goods and services suppliers which will result in improved livelihoods.

On a broader scale, the establishment of the proposed ancillary infrastructure will positively support the planned Temo Mine operation. Through this ancillary infrastructure, Temo Mine is ensuring that the project is optimised as far as possible. The diversion of the D175 road will ensure that the targeted coal reserve is accessible to its full extent while also reducing public health; and safety risks associated with having road in proximity to mining area. Through establishment of the rail loop and associated rail link, Temo Coal intends to leverage off existing and planned rail infrastructure to effectively and efficiently transport coal to the intended markets.

The proposed water pipeline between the Lephalale WWTW and Temo Mine will secure a water source for operational activities at the mine, which is sustainable in the water scarce region. The key negative implications associated with establishing the ancillary infrastructure include the loss of topsoil resources as result of soil erosion and total loss of 79 hectares of natural habitat. This, in some parts, includes habitat that supports red data species and species of special concern (SSC).

Lastly, it was also argued in Digby wells, (2019) that if the road diversion does not go ahead, the production of coal at the Temo Mine would not be viable. If the rail loop is not constructed, the cost to Temo for the transportation of coal would increase due to the need to transport export coal via road using coal trucks. The road network will also be negatively impacted due to the increased usage of the roads by coal trucks. If the pipeline does not go ahead, it would mean that the Temo Mine will not be able to remain operational as there is no other long-term solution which is deemed feasible for water supply to the Temo Mine to run operations.

4.3 SYNTHESIS

As the focus of the study was the sustainability of post-mining land use planning, *inter alia*, it makes it worthwhile for me to extend the two-way methodology to further analyse the I&APs' input that allowed a better understanding of whether the regulatory authorities, and the stakeholders themselves were interested in post-mining land use, not to mention land use planning. The approach adopted in the case discussion provided me with insights into the role of stakeholders as advocates for post-mining land use planning, as the proponent or EAP would possibly not consider reporting what is not of interest to the stakeholders, as well as terms of reference of the applicant.

The case studies demonstrated that public consultation is two-way process, where information about proposal was disseminated. The consultation process records the community's concerns, interests, and aspirations for these to be addressed in the reports. The proponent, or EAP was required to compile list of I&APs, and develop methods for notifying them about processes, as a standard procedure. However, I was somewhat concerned about the language in which the reports were presented to the stakeholders. For instance, the proponents of case study 1 identified that the I&APs were mostly uneducated and were conversant with IsiZulu. The consultations were conducted in language of choice of the community members, which is mainly IsiZulu. However, notices, as well as the final report were only in English.

Similarly, the other case studies also used English to notify and engage with stakeholders whose preferred languages are Sepedi, Afrikaans, Xitsonga, and Setswana. This left me pondering whether the conspicuous absence of post-mining land use planning in EIA reports was partly due to stakeholders' lack of understanding of the language used in the reports and/or whether stakeholders' input really contributed to competent authority decision-making in approving EIA. When conducting an EIA, there is a need to have background information of the area for which the development is intended (Aucamp, 2009). This can assist in determining whether similar studies were carried out in the area, which the EAP can also use in compiling the assessment report.

The EIAs reviewed, have shown that comparison with EIA methods in similar projects, expert opinion, specialist studies, risk assessment, professional judgment, overlays, and geographic information system (GIS), photography, landscape evaluation, and literature review were used during the assessment. As part of the assessment, a specialist was consulted regarding the effect of the development of the flora and fauna in the area, and findings indicated that the development could have a negative impact on certain species. However, the ecosystem can be mitigated by implementing proposed management and monitoring measures. Geographic information, such as aerial photography of the site, land use, zoning, topographical mapping, and cadastral information were also taken into consideration and maps were provided in all the EIAs. Specialist studies were done in all three the EIAs. Although the approach and expertise used in each EIA were different, the projects were found to be viable and the impact found in each could be mitigated.

Land use planning (LUP) in the case-studies only support rehabilitation, which is a major component of any life of mine (LoM). However, this study was to assess post-mining land use planning beyond LoM. A recommendation for land rehabilitation and impact mitigation measures in any EIA report is not a sustainable postmining land use plan. In rehabilitation, the applicant is only reinstating the area, as closely as possible, to that which existed pre-mining. There is nothing new in providing for rehabilitation in EIA – it is a standard practice. The various projects have benefits in terms of local employment, local economic development, and increased government revenue and taxes. However, the expansion of industrial activity, while promoting economic growth, has led to encroachment on agricultural land as the most dominant land use within the mining right area is agricultural activities such as farming and livestock keeping.

The conventional approach of granting mining rights based on the factors highlighted in this dissertation also did not weigh the benefits of Agricultural activities as a sustainable land use option as opposed to the grounds sort in the case studies. My findings with regards to conspicuous absence of land use planning in these case studies suggests that this trend is also not peculiar to South Africa. According to Minerva, (2019) the discourse on mine closure is informed predominantly by industry and corporate perspectives and predicated by experiences of mining companies that are in developed countries where necessary planning frameworks and regulatory requirements are well-established. Mine closure planning, well promoted and accepted as good business practice in the global minerals industry, has been primarily technical and precautionary both in approach and focus. Planning, modelling, and monitoring strategies in mine closure incorporate as comprehensive and detailed as possible elements such as properties inherent in landforms, climate, geology, flora and fauna, among others. However, locality-based concerns that revolve around resource access and tenure, rights and entitlements tied to locality and indigeneity, labour recruitment, workers' mobility, and other non-bio-physical elements are hardly examined. Any mine closure program that disregards these elements is deficient and therefore ineffective (Minerva, 2019).

I have provided plethora of evidence in South Africa and many other mining jurisdictions where abandoned mines has been rehabilitated for other viable non-mining business ventures, but I am of the view that in these countries as well as in South Africa, my findings suggest that they did not consider post-mining land use pre-mining, because the trends in all the cases shows that projects were only developed several decades after the mine has closed or abandoned.

CHAPTER 5: CONCLUSION

5.1 INTRODUCTION

This research was conducted, *inter alia,* to determine whether environmental impact assessment (EIA) could be an instrument that enhances the capacity of a mine to attain its rehabilitation objectives by understanding the demands for sustainable post-mining land use. Specific objectives that guided the study were:

- To conduct a regulatory framework review of mining EIA reports as instrument for planning and decision-making within the South African mining context. The purpose of the regulatory framework review was to highlight the various processes of EIA reports, what changes have been made in the various regimes, and whether regulatory reforms and amendments contributed to sustainable post-mining land use, and if so, in what way.
- To conduct a detailed review of mining EIA reports in South Africa. This was done to provide an understanding of whether, inter alia, I&APs' participation and input were considered in the EIA reports, and whether the stakeholders referred to post-mining land use in the public participation other than in terms of the immediate obvious benefits such as employment opportunities and environmental impact mitigations.

These objectives have been achieved as presented in the results. The literature review sets the scene to highlight the regulatory frameworks and transitions of EIA regimes in South Africa. Further review of literature (Carrick & Kruger, 2007; Limpitlaw, 2004; Limpitlaw & Woldai, 2000) demonstrated that several external and country-specific statutory and corporate strategies and planning techniques have been established, often producing step-by-step directions to the fundamental aspects that need to be included as part of mine rehabilitation and closure timing.

5.2 LAND USE AND MINING EIAs

Mining is the fifth biggest economic sector globally and has an important role to play in buttressing the success for future generations, and South Africa is known to retain 3.5% of global mining investments (Chamber of Mines, 2017).

Most of the research on end-mine land use has failed to consider the overarching environmental impact assessment (EIA) sphere in which the impact and its subsequent management can be accurately defined, from a sustainable post-mining land use perspective. In line with foregoing, and literature reviewed to address the study objectives, the following is apparent in the context of South African mine rehabilitation, land use, and EIAs:

- Several mining laws and regulations are often poorly positioned, with different environmental compliance prerequisites from different agencies. It consequently creates confusion about who the principal government body is or with whom government-industry interactions should take place.
- South Africa has a wide variety of well-written, up-to-date regulations that govern the rehabilitation and closure of mining operations. Even so, in a nation where there is a serious lack of environmental compliance, real adoption towards satisfactorily rehabilitated mine land is unlikely.

An EIA is both a direction-giving and a judgment-making instrument and to some extent guarantees that construction initiatives do not have expensive ecological and societal effects. Nonetheless, EIAs may have little effect on policy-making if the method relies heavily on end results. In particular, the EIA functions are somewhat of a risk reduction activity, even though the potential of halting projects is comparatively rare in situations where proposals are deemed to be of national interest and politically significant, as argued by Van Zyl, et al. (2002).

5.3 EIA AND LEGISLATION

In the case studies, postmining land use from perspective of planning for the development of alternative sustainable economic venture post-mining, *inter alia*, necessitated the various mining EIA reports to be considered. Katima (2003) observed that an efficient and sustainable EIA system depends, among other variables, on political will, and an EIA is needed for any development initiative to proceed (Aucamp, 2009). It has also been noted that not all the legislation specified in the NEMA Regulations has been utilised, and the EIAs may have applied legislation that is relevant to them. Public engagement is also being drawn into consideration. In addition, a comparative analysis of the three EIAs was done. The legislation used in the evaluation of all three EIAs has been discussed.

5.4 EIA AND STAKEHOLDER ENGAGEMENT

A study by Glenn, et al. (2014) shows that, in several instances, there seems to be inappropriate support for mining businesses on how to achieve specific restoration objectives, intentions, and tracking mechanisms. In cases where there is no awareness on land rehabilitation standards, it also becomes difficult for businesses to be assured that their rehabilitation will be considered favourable by authorities.

It is observed that, regardless of the extensive and forward-looking stance taken by local legislators and regulators, the effective application and execution of the rehabilitation policies specified are often a feature of stakeholder participation, regulators, and enforcement authorities. Community inclusivity could promise more restoration possibilities, solely based on improved geographic footprint for improvement of ecological habitat and productive land, as well as urban growth.

These solutions need to be matched with the demands of I&APs, both impacting on environment; and perhaps even affecting its sustainable land use capacity. These aspirations are often described by business fundamental principles that differentiate between the accomplishment of minimum legislative demands (accountability) and the achievement of global best practice (governance).

5.5 SUMMARY

The three-case study used in this research provided a comprehensive overview of strategic plans for mine rehabilitation, covering different phases of mining operations but with conspicuous absence of post-mining land use planning from a construction; operational; rehabilitation, closure and decommissioning phase perspective. Rehabilitation requires that activities that can occur during these established phases of the mine life cycle are restricted to planned areas to reduce the footprint, control pollution, and remove alien invasive vegetation.

In all three case studies, rehabilitation was also required for the surface infrastructure until the end of life of the mine, thereafter it was necessary that vegetation cover must be successfully established. These overarching rehabilitation plans left me pondering where the post-mining land use plan in all of this is. Hence, I sought answers to the research question posed in this study.

Furthermore, I found that the development of an appropriate land restoration strategy in the early phases of mine planning, including specified end-use objectives, was essential for the development of suitable socio-economic post-mining objectives that can be negotiated with the authorities and various stakeholders. This could significantly help to reduce and mitigate the adverse environmental and socio-economic effects of mining. It can also assist in providing feasible, plausible mining end land use, developing local abilities, creating work opportunities, and improving long-term viable livelihoods for the I&APs. According to Marais and Lange (2020) long-term planning must anticipate not just growth but the likelihood of decline. They further argued in the context of South Africa, that its problems stem from inappropriate post-apartheid policies, the power of the mining companies, the relaxation of planning legislation, a planning mindset that promotes growth, and a reluctance to plan for decline.

I found that the EIA reports reviewed did not contribute to the sustainable post-mining land use planning in the South African mining sector. However, the mining EIA reports extensively covered the environmental components, particularly the specialist studies, as they assessed whether projects conformed with the regulatory requirements. The emphasis of the mining EIA reports was mainly on the environmental component, with no post-mining land use and socio-economic impact indicators besides employment and economic benefits.

These trends were found to be further reinforced when the input of the I&APs was analysed. The focus of the I&APs was mainly on socio-economic themes. Meeting basic human needs, such as employment, shelter, food, water, electricity, and security, etc were most dominant, although environmental risks were also prioritised in the reports. Post-mining land use (except for rehabilitation) or post-mining economy, on the other hand, did not feature in the case studies.

5.6 RECOMMENDATIONS

In view of the findings of this study, the main recommendations to improve EIA systems would be to:

- clarify and simplify the mandates of the several institutions involved in the EIA process and system;

- improve and increase public access to EIA reports, including electronic means. This is pertinent due to the conspicuous absence of EIA reports in the public domain, which contributed to the limited number of EIA reports that were reviewed in this dissertation. These type of engagement would have been most appreciated should EIA reports become available in the public domain, even my attempts to obtain EIA reports were rebuffed. I therefore state that EIA reports are public documents and not a state secret or classified document, that requires a court order to access.
- Public participation processes (PPP) should be conducted in most common languages of the stakeholders; and
- Specialist social impact assessment should go beyond the traditional socio-economic issues faced by I&APs to include post-mining land use, as well as sustainable post-mining economy.

From a sustainability standpoint, I am of the view that the decision of any competent authority to approve an EIA report should take into account the environmental and socio-economic impact of post-mining land use. Therefore, I somewhat disagree that employment, supply, and procurement opportunities for the locals, and revenue to the national economy can be the most significant basis or overriding factor to warrant EIA approval because when the commodity price drops, massive retrenchments take place and no more revenue accrues to government. According to Minerva, (2019) to a mining company, a mine closure undertaking is a project that it implements in compliance with closure regulations. But to the host communities, the mine closure process which involves their participation in many forms and at varying degrees, both voluntary and involuntary, is a social episode in their pathways and transitions. Implementing a mine closure plan is a form of an intervention which, in development theory and practice, aims to bring a positive change (Minerva, 2019).

In most instances, the mine is closed or abandoned and the primary basis for initially approving the EIA no longer hold. So, what happens to the community regarding the environment? Where are the jobs that were promised to landowners to vacate the land? What about the social dislocations post-mining? How are these social issues acknowledged and dealt with in the EIA reports and are there any mitigation measures post-mining? Are employment and compensation commensurate with the position the locals would have been in but for the socio-economic losses pre-mining? Who determines what the compensation would be and on what basis it would be allocated?

These questions and many more remain unanswered in the various EIA regime changes, and case studies reviewed in this dissertation. Nonetheless, post-mining land use planning exemplifies a core societal challenge in that it needs scrutiny and assimilation of environmental, socio-economic, political, and financial forces operating over a time and space. I am yet to find any mining EIA report that shaped the part to sustainable post-mining land use, a land use that is integrated as Life of Mine.

REFERENCES

Ackerman, M., Waldt, G. and Botha, D. 2017. Mitigating the socio-economic consequences of mine closure. *The Journal of Southern African Institute of Mining and Metallurgy*, 118:439-447.

African Development Bank, and United Nations Economic Commission for Africa. 2012. Building a sustainable future for Africa's extractive industry: from vision to action. Action plan for implementing the AMV. Addis Ababa: Africa Mining Vision.

African Union Commission, United Nations Economic Commission for Africa, and African Development Bank. 2012. The African minerals development centre business plan. Minister of Mines of the Federal Republic of Ethiopia, and Chairperson of the Bureau of the Second AU Conference of Ministers Responsible for Mineral Resources Development; Addis Ababa, Ethiopia.

African Union. 2009. African mining vision. Addis Ababa: African Union.

African Union. 2013. The country mining vision-CMV. Bamako: African Union. African Union Commission,

Akbari A D., Osanloo M. and Hamidian H. 2006. Selecting post mining land use through analytical hierarchy processing method: case study in Sungun copper open pit mine of Iran. *15th International Symposium on Mine Planning and Equipment Selection*, Torino, Italy, 19-22 September.

Alexander, N. 2010. Kolmanskop: An industrial heritage resource or only a tourist attraction? The Assessment of value with regard to Kolmanskop ghost town and the industrial landscape of the Sperrgebiet National Park, Namibia. *MPhil Dissertation*. Cape Town: University of Cape Town.

Anglo American. 2013. Mine Closure Toolbox, version 2. Available online at: https://www.angloamerican.com/~/media/Files/A/Anglo-American-PLC V2/documents/approach-and-policies/environment/toolbox-main-brochure-lr.PDF. [Accessed on 28 August 2019].

Antwi, E.K., Krawczynski, R., and Wiegleb, G. 2008. Detecting the effect of disturbance on habitat diversity and land cover change in a post-mining area using GIS. *Landscape and Urban Planning*, 87:22–32.

Aucamp, P.J. 2009. Environmental Impact Assessment: A practical guide for the discerning practitioner. Van Schaik. Pretoria.

Audet, P., Arnold, S., Lechner, A.M. and Baumgartl, T. 2013. Site-specific climate analysis elucidates revegetation challenges for post-mining landscapes in eastern Australia. *Biogeosciences*, 10:6545-6557.

Australian Bureau of Agricultural and Resource Economics and Sciences. 2011. Guidelines for land use mapping in Australia: principles, procedures and definitions. 4th edition.

Australian Department of Industry, Tourism and Resources. 2006. Mine Rehabilitation: Leading Practice Sustainable Development Program for the Mining Industry.

Azapagic, A. 2004. Developing a framework for sustainable development indicators for the mining and minerals industry. *Journal of Cleaner Production,* 12:639-662.

Baartjes, N.L. and Gounden, K.G. 2012. Causes of Mine Decline in South Africa, Johannesburg: EcoPartners.

Bailey, T. and Hooey, C. 2017. From wasteland to wonderland: New uses for mined land in rural Southeast Kansas. *Midwest Quart*. 58:252.

Balsam, A. and Wood, C. 2002. A Comparative Evaluation of the EIA Systems in Egypt, Turkey and Tunisia. *Environmental Impact Assessment Review*, 22, 213-234. https://doi.org/10.1016/S0195-9255(02)00004-5.

Bangian, A.H., Ataei, M., Sayadi, A. and Gholinejad, A. 2012. Optimizing post-mining land use for pit area in open-pit mining using fuzzy decision-making method. *Int. J. Env. Sci. Techn*. 9:613-628.

Baral, H., Keenan, R.J., Sharma, S.K., Stork, N.E. and Kasel, S. 2014. Economic evaluation of ecosystem goods and services under different landscape management scenarios. *Land Use Policy*. 39:54-64.

Bascetin, A. 2007. A decision support system using analytical hierarchy process (AHP) for the optimal environmental reclamation of an open-pit mine. *Environmental Geology*, 52(4):663-672.

Bateman, I.J. 2009. Bringing the real world into economic analyses of land use value: incorporating spatial complexity. *Land Use Policy*. 26:30-42.

Bazzazi, A. A., Osanloo, M. and Karimi, B. 2011 Deriving preference order of open pit mines equipment through MADM methods: Application of modified VIKOR method. *Expert Systems with Applications*, 38(3):2550-2556.

Bell, F.G., Stacey, T.R. and Genske, D.D. 2000. Mining subsidence and its effect on the environment: Some differing examples. *Environ. Geol*. 40, 135-152.

Borzel, T. and Gupta, J. 2000. A New North-South Conflict: Regulatory Competition in European and International Environmental Politics. Part of the proceedings of the Final Conference on the Effectiveness of International Environmental Agreements and EU Legislation. Available at http://www.fni.no/ca/borzel-gupta.pdf. [Accessed on 21 May 2019].

Botha, I. 2014. Aquaponics as a productive rehabilitation alternative in the Mpumalanga Highveld Coalfields. Master's Thesis. University of Bloemfontein. 55-97.

Bowman, B. and Baker, D. 1998. Mine Reclamation Planning in the Canadian North. *Northern Minerals Program, Working Paper No. 1*. Canadian Arctic Resources Committee, Ottawa. Pp. 82.

Boyer, J. 2015. Mine closure: Canada's policy framework. Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development.

Brömme, K., Greassidis, S., Jolk, C. and Stolpe, H. 2015b. Mine Closure-An Important Environmental and Economic Task in Vietnamese Mining Industry. *Paper and presentation at 2nd International Conference on Economic Management in Mineral Activities,* Nov 14-15, 2015, Hanoi, Vietnam.

Brömme, K., Stolpe, H., Jolk, C., Greassidis, S., Borgmann, A., Zindler, B. and Mien, T. 2015a. Development of methods for post-mining land use planning for coal mines in urban areas in Quang Ninh, Vietnam.

Brooks, R.R. and Robinson, B.H. 1998. The potential use of hyperaccumulators and other plants for phytomining. In: Brooks, R.R. (Ed.), Plants that Hyperaccumulate Metals: Their Role in Archaeology, Microbiology, Mineral Exploration, Phytomining and Phytoremediation. CAB International, Wallingford. pp. 327-356.

Brooks, R.R., Robinson, B.H., Howes, A.W. and Chiarucci, A. 2001. An evaluation of Berkheya coddii Roessler and Alyssum bertolonii Desv. for phytoremediation and phytomining of nickel. *South African Journal of Sciences,* 97(2):558-560.

Bureau for Food and Agricultural Policy. 2012. The impact of coal mining of agriculture-a pilot study. pp. 8.

Bureau for Food and Agricultural Policy. 2015. The balance of natural resources: understanding the long-term impact of mining on food security in South Africa. 31-36.

Canadian Aboriginal Affairs and Northern Development Canada and Land and Water Boards of The Mackenzie Valley. 2013. Guidelines for the development of closure and reclamation plans for advanced mineral exploration and mine sites in the Northwest Territories, 10.

Cao, X. 2007. Regulating mine land reclamation in developing countries: the case of China. *Land Use Policy*, 24:472-483.

Carrick, P.J. and Kruger, R. 2007. Restoring degraded landscapes in lowland Namaqualand: Lessons from the mining experience and from regional ecological dynamics. *Journal of Arid Environments*, 70:767-781.

Chamber of Mines SA. 2015. Gold production 1902-2013. Available online at: http://www.chamberofmines.org.za/mining-industry/gold. [Accessed on 20 January 2019].

Chamber of Mines South Africa (CoM). 2011. Facts and Figures 2010, Johannesburg: Chamber of Mines South Africa.

Chen, J., Li, K., Chang, KJ., Sofia, G. and Tarolli, P. 2015. Open-pit mining geomorphic feature characterisation. *Int J Appl Earth Obs* 42:76–86.

Choshi, S. 2001. Mining and society-local development, MMSD Southern Africa Report on Research Topic 3, (ed.) P. Kapelus, AICC, pp. 59.

Claassen, P., Hall, J. and Ebrahim, S. 2003. *Discussion paper on the preparation of the environmental impact management regulations*. DEAT Briefing Note, 26 November 2003. Pretoria: Department of Environmental Affairs and Tourism.

Colpaert, A. 2006. The Forgotten Uranium Mine of Paukkajanvaara, North Karelia, Finland. *Nordia Geogr. Publ*. 35:31-38.

Collis, J. and Hussey, R. 2009. *Business Research: A practical guide for undergraduate and postgraduate students.* 186-187. Hampshire: Palgrave Macmillan.

Cooke, J.A. and Limpitlaw, D. 2003. *Post-Mining Site Regeneration: Review of Good Practice in South Africa,* unpublished report for the Global Mining Consortium, Global Centre for Post-Mining Regeneration, Cornwall, UK.

Cooke, JA. and Johnson, MS. 2002. Ecological restoration of land with particular reference to the mining of metals and industrial minerals. *Environ Rev*iew. 10:41–71.

Danielson, L. 2006. Architecture for Change: An Account of the Mining, Minerals and Sustainable Development Project, Berlin: Global Public Policy Institute.

De Groot, R. 2005. Function-analysis and valuation as a tool to assess land use conflicts in planning for sustainable, multi-functional landscapes. *Landscape and Urban Planning*, 75:175-186.

DEA&DP workshop. 2006. Manual on the Environmental Impact Assessment Regulations, National Environmental Management Act, 1998 (Act No. 107 of 1998). In: Strategic Environmental Focus and Kantor Legal Services, editors. Workshop on the new EIA Regulations promulgated in terms of NEMA (Act No. 107 of 1998), Western Cape Department of Environmental Affairs and Developmental Planning; 2006 Nov 6-7; Durbanville, Cape Town.

DEAT, 2004. Overview of Integrated Environmental Management. *Integrated Environmental Management, Information Series 0*, Department of Environmental Affairs and Tourism (DEAT), Pretoria.

DEAT, 2006. *Presentation on the revised National Environmental Management Act: environmental impact assessment regulations.* Presented by Lize McCourt of the Department of Environmental Affairs and Tourism at the monthly South African IAIA Vaal branch meeting, April 2006, Midrand.

DEAT, 2008a. Capacity audit and needs analysis survey for environmental impact assessment administrators. Pretoria: Department of Environmental Affairs and Tourism.

DEAT, 2008b. Draft report: review of the effectiveness and efficiency of the environmental impact assessment (EIA) system in South Africa. Pretoria: Department of Environmental Affairs and Tourism.

Department of Environmental Affairs (DEA). 2010. South African Country Report for the Eighteenth Session of the United Nations Commission on Sustainable Development (CSD-18), Pretoria: DEA.

Department of Environmental Affairs (DEA). 2011. National Strategy for Sustainable Development and Action Plan (NSSD 1): 2011-2014, Pretoria: DEA.

Department of Environmental Affairs and Tourism (DEAT). 1998. National Environmental Management Act, Act No. 107, 1998, Pretoria: DEAT.

Department of Environmental Affairs and Tourism (DEAT). 2003. Johannesburg Plan of Implementation on Sustainable Development- JPOI Response Strategy, Pretoria: DEAT.

Department of Minerals and Energy (DME). 2002. Mineral and Petroleum Resources Development Amendment Act, No. 28 of 2002, Pretoria: DME.

Department of Minerals and Energy (DME). 2007. A Strategic Framework for Implementing Sustainable Development in The South African Minerals Sector: Towards Developing Sustainable Development Policy and Meeting Reporting Commitments, Pretoria: DME.

Department of Minerals and Energy (DME). 2008. Mineral and Petroleum Resources Development Amendment Act, No. 49 of 2008, Pretoria: DME.

Department of Water Affairs and Forestry (DWAF).1999. National Water Amendment Act, Act No. 45 of 1999, Pretoria: DWAF.

Digby Wells. 2017. Rehabilitation, Decommissioning and Mine Closure Plan for the Thubelisha, Trichardtsfontein and Vaalkop Mining Right Areas. DWA: Johannesburg.

Digby Wells. 2019. Environmental Impact Assessment and Environmental Management Programme Report for the Proposed Rail Loop, Road Diversion and Project associated with the Temo Coal Mine, Limpopo Province. DWA: Johannesburg.

Doley, D., Audet, P. and Mulligan, D. 2012. Examining the Australian context for post-mined land rehabilitation: reconciling a paradigm for the development of natural and novel ecosystems among post-disturbance landscapes. *Agriculture, Ecosystems and Environment,* 163:85-93.

Donnelly, A, Barry, D. and Ross, H. 1998. A Directory of Impact Assessment Guidelines. Second edition. International Institute for Environment and Development.

Duthie, A. 2001. A Review of Provincial Environmental Impact Assessment Administrative Capacity in South Africa. *Impact Assessment and Project Appraisal*, 19:215-222.

Economic Commission for Africa and African Union. 2011. Minerals and Africa's development: the international study group report on Africa's mineral regimes. Addis Ababa: United Nations Economic Commission for Africa

Edraki, M., Baumgartl, T., Manlapig, E., Bradshaw, D., Franks, D.M. and Moran, C.J. 2014. Designing mine tailings for better environmental, social and economic outcomes: A review of alternative approaches. *Journal of Cleaner Production.* 84:411-420.

Edwards, J.A. and Coit, J.C.L. 1996. Mines and quarries: Industrial heritage tourism. *Ann. Tour. Res*. 23:341-363.

Environmental Impact Management Services (EIMS). 2017. Vlakvarkfontein coal mine extension, associated infrastructure and amendments to existing licence conditions. Environmental. EIMS: Johannesburg.

Environmental Impact Management Services (EIMS). 2018. Environmental Impact Assessment Report. Environmental. EIMS: Johannesburg.

Ekener, E., Hansson, J., Larsson, A. and Peck, P. 2018. Developing Life Cycle Sustainability Assessment methodology by applying values-based sustainability weighting - Tested on biomass based and fossil transportation fuels. *Journal of Cleaner Production*, 181:337-351.

Fields, S. 2003. The earth's open wounds: Abandoned and orphaned mines. *Environ. Health Perspect*, 111:154.

Finucane, S.J. 2008. Thinking about the end before you start-integrating mine closure planning into feasibility studies and environmental and social impact assessment. Mine Closure, Proceedings of the Third International Seminar on Mine Closure. Johannesburg, South Africa, 14-17 October 2008.

Glasson, J. and Salvador, NNB. 2000. EIA in Brazil: a procedure – practice gap. A comparative study with reference to the European Union, and especially the UK. *Environ Impact Asses Rev*. 20: 191 – 225.

Glasson, J., Therivel, R. and Chadwick, A, 2006. *Introduction to environmental impact assessment*, 3rd ed., London: Routledge.

Glenn, V., Doley, D., Unger, C., McCaffrey, P., Gillespie, M. and Williams, E. 2014. Mined land rehabilitation-is there a gap between regulatory guidance and successful relinquishment? *Mine Rehabilitation Bulletin*, 48-54.

Global Mining (World Bank Group: Mining Department). 2002. Treasure or Trouble? Mining in Developing Countries, Washington, DC: International Finance Corporation.

Golafshani, N. 2003. Understanding Reliability and Validity in Quantitative Research. *The Qualitative Report of University of Toronto*, 597-607.

Gross, M. 2008. Population decline and the new nature: Towards experimental “refactoring” in landscape development of post-industrial regions. *Futures*. 40, 451-459.

Guiro, D. and Cooper, C. 2012. Mining and sustainability: Asking the right questions. *Minerals Engineering*, 29, 3-12.

Gutierrez, M., Mickus, K. and Camacho, L.M. 2016. Abandoned Pb Zn mining wastes and their mobility as proxy to toxicity: A review. *Sci. Total Environ*. 565, 392-400.

Haque, M.A., Topal, E. and Lilford, E. 2014. A numerical study for a mining project using real options valuation under commodity price uncertainty. *Res. Pol*. 39:115-123.

Hattingh, R. 2018. Framework to guide mine-related land use planning towards optimisation of the coal mining rehabilitated landscape. *Masters Dissertation*. University of Pretoria.

Heikkinen, P.M.; Noras, P. and Salminen, R. 2008. Mine Closure Handbook. In Environmental Techniques for the Extractive Industries; Geological Society of Finland: Sastamala, Finland, 2008; p. 169. Available online: http://tupa.gtk.fi/julkaisu/erikoisjulkaisu/ej_074.pdf. [Accessed on 20 August 2019].

Heikkinen, P.M.; Noras, P. and Salminen, R. 2008. Mine Closure Handbook. In Environmental Techniques for the Extractive Industries; Geological Society of Finland: Sastamala, Finland, 2008; p. 169. Available online at http://tupa.gtk.fi/julkaisu/erikoisjulkaisu/ej_074.pdf. [Accessed on 20 August 2019].

International Council on Mining and Metals (ICMM). 2008. Planning for integrated mine closure: toolkit. London: ICMM.

International Council on Mining and Metals. 2011. The role of mining and metals in land use and adaptation.

International Finance Corporation (IFC). 2007. Environmental, health and safety guidelines for mining. Washington (DC): IFC, World Bank Group.

Jeromino, P.R., Rap, E. and Vos, J. 2015. The politics of Land Use Planning: Gold mining in Cajamarca, Peru. *Land Use Policy,* 49:104-117.

Jolliffe, L. and Conlin, M. 2010. Lessons in transforming mines into tourism attractions: A Global Synth. *Min. Herit. Tour*. 241:20.

Kangwa, KP. 2008. An assessment of the economic, social and environmental impacts of the mining industry: a case study of copper mining in Zambia. *Master thesis*, Lund University, Sweden.

Katima, J. 2003. Environmental Impact Assessment: For Whose Needs? In UNEP EIA Training Resource Manual: Case Studies from Developing Countries.

Keeling, A. and Sandlos, J. 2017. Ghost towns and zombie mines: The historical dimensions of mine abandonment, reclamation, and redevelopment in the Canadian North. In Ice Blink: Navigating Northern Environmental History; Bocking, S., Martin, B., Eds.; University of Calgary: Calgary, AB, Canada, pp. 377-420.

Kim, S.M., Suh, J., Oh, S., Son, J., Hyun, C.U., Park, H.D., Shin, S.H. and Choi, Y. 2016. Assessing and prioritizing environmental hazards associated with abandoned mines in Gangwon-do, South Korea: The Total Mine Hazards Index. *Environ. Earth Sci*. 75, 1-14.

Kirk, J. and Miller, M. 1986. *Reliability and Validity in qualitative research.* Beverly Hills: Sage Publications.

Kivinen, S. 2017. Sustainable Post-Mining Land Use: Are Closed Metal Mines Abandoned or Re-Used Space? *Sustainability*. 9,1705; doi:10.3390/su9101705.

Kotilainen, J., Prokhorova, E., Sairinen, R. and Tiainen, H. 2015. Corporate social responsibility of mining companies in Kyrgyzstan and Tajikistan. *Res. Pol.* 45:202-209.

Kretschmann, J. and Hegemann, M. 2012. New chances from old shafts. Risk management in abandoned mine sites in Germany. Proceedings of the Annual Meeting of the Society for Mining, Metallurgy & Exploration, 153-158. Seattle, Washington: Curran Associates, Red Hook, NY.

Kretschmann, J. 2018. Post-mining excellence: strategy and transfer. *Journal of the Southern African Institute of Mining and Metallurgy*, 118:853-859.

Kubit, O.E., Pluhar, C.J. and De Graff, J.V. 2015. A model for prioritizing sites and reclamation methods at abandoned mines. *Environ. Earth Sci*. 73:7915-7931.

Lamb, D., Erskine, P.D. and Fletcher, A. 2015. Widening gap between expectations and practice in Australian mine site rehabilitation. *Ecol. Manag. Restor.* 16:186-195.

Laurence, D. 2006. Optimisation of the mine closure process. *Journal of Cleaner Production*, 14:285-298.

Laurence, D. 2011. Establishing a sustainable mining operation: An overview. *Journal of Cleaner Production*. 19, 278–284.

Lechela, N. 2018. Ben Magara: 12 600 Lonmin jobs depend on Sibanye deal. Available online at Fin24: https://www.fin24.com/Companies/Mining/ben-magara-12-600-lonmin-jobs-depend-on-sibanye-deal-20180514. [Accessed 4 January 2019].

LeClerc, E. and Keeling, A. 2015. From cut lines to traplines: Post-industrial land use at the Pine Point mine. *Extr. Ind. Soc*. 2:7-18.

Lei, K., Pan, H. and Lin, C. 2016. A landscape approach towards ecological restoration and sustainable development of mining areas. *Ecol. Eng*. 90: 320-325.

Leu, W.S., Williams, W.P. and Bark, A.W. 1997. Evaluation of Environmental Impact Assessment in Three Southeast Asian Nations. *Project Appraisal*, 12, 89-100. https://doi.org/10.1080/02688867.1997.9727045.

Li, M.S. 2006. Ecological restoration of mine land with particular reference to the metalliferous mine wasteland in China: A review of research and practice. *Sci. Total Environ*. 357, 38–53.

Limpitlaw, D. 2004. Mine closure as a framework for sustainable development. Sustainable development practices on mine sites: tools and techniques, 1-11. Witwatersrand: University of the Witwatersrand.

Limpitlaw, D., Aken, M., Lodewijks, H. and Viljoen, J. 2005. Post-Mining Rehabilitation, Land Use and Pollution at Collieries in South Africa, Presented at the Colloquium: Sustainable Development in the Life of Coal Mining, 13 July, 2005, September 2004, Boksburg, South Africa.

Limpitlaw, D. and Briel, A. 2014. Post-mining land use opportunities in developing countries-a review. *The Journal of The Southern African Institute of Mining and Metallurgy.* 114:899-903.

Limpitlaw, D. and Woldai, T. 2000. Land use change detection as an initial stage in environmental impact assessment on the Zambian Copperbelt. In: Proceedings of 28th ISRSE: Information for Sustainable Development, Cape Town.

Lintukangas, M., Suihkonen, A., Salomäki, P. and Selonen, O. 2012. Post-mining solutions for natural stone quarries. *J. Min. Sci*. 48, 123–134.

Macfarlane, A. 2018. Presidential address: Towards the future: African Mining Vision, Mining Phakisa and the SAIMM. *Journal of the Southern African Institute of Mining and Metallurgy*, 118:899-916.

Maczkowiack, R.I., Smith, C.S., Slaughter, G.J., Mulligan, D.R. and Cameron, D.C. 2012. Grazing as a post-mining land-use: A conceptual model of the risk factors. *Agric. Syst*. 109:76-89.

Mancini, L. and Sala, S. 2018. Social impact assessments in the mining sector. Review and comparison of indicators frameworks. *Resource policy*, 57:98-111.

Marais, L and Atkinson, D. 2006.Towards a post-mining economy in a small town: challenges, obstacles and lessons from South Africa. Paper presented at the Desert Knowledge Conference. Alice Springs, Australia 2-4 November. 1-18.

Marais, L. 2013. The Impact of Mine Downscaling on the Free State Goldfields.

Urban Forum.1-22.DOI: 10.1007/s12132-013-9191-3

Marais, L and Lange, A. 2020. Anticipating and planning for mine closure in South. Africa. Futures. DOI:10.1016/j.futures.2020.102669.

Masoumi, I. and Rashidinejad, F. 2011. Preference ranking of post-mining land use through LIMA framework. 9th International Conference on Clean Technologies for the Mining Industry. 10-12 April 2011. Santiago, Chile.

Mborah, C., Bansah, K.J. and Boateng, M.K. 2015. Evaluating alternate post-mining land-uses: A review. *Env. Poll*. 5-14.

McHaina, D.M. 2001. Environmental planning considerations for the decommissioning, closure and reclamation of a mine site. *Int. J. Surf. Min. Reclamat. Environ.* 15:163-176.

Mercer-Mapstone, L., Rifkin, W., Louis, W., & Moffat, K. 2017. Meaningful dialogue outcomes contribute to laying a foundation for social licence to operate. *Resources Policy*. 53:347-355. doi:10.1016/j.resourpol.2017.07.004.

Miller, D. 2008. Using aquaculture as a post-mining land use in West Virginia. *Mine Water Environ*. 27, 122.

Mitchell, R.K., Agle, B. and Wood, D.J. 2008. Toward a theory of stakeholder identification and salience: defining the principle of who and what really counts. *Academy of Management Review*, 224:12-21.

Minerva, C.M. 2019. Mine closure: anticipating the end before the beginning. In Social Terrains of Mine Closure in the Philippines.1-16: Routledge.

Modak, P., Asit, K. and Biswas, E. 1999. Conducting environmental impact assessment in developing countries. Tokyo. United Nations University Press.

Mohring, R.P., Phillips, H., Morgan, P.M., Grobbelaar, C.J., Stewart, J.M. and Riet, V. 2001. South African coal related research and development, 2000/2001. *Country Report to the International Committee for Coal Research*. Prepared by the South African ICCR Delegation, 26th ICCR meeting, Strasbourg, France, 23-24 October.

Morgan, R. 2012. Environmental impact assessment: the state of the art. *Impact Assess Project Appraisal*. 30:(1):5-14. doi:10.1080/14615517.2012.661557.

Mu, Y., 2006. Developing a suitability index for residential land use: a case study in Dianchi Drainage Area. A Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of Science in Environmental Studies in Geography. Waterloo, Ontario, Canada.

Ndaba, M. 2010. Mining and local economic development: A case study of the Rustenburg local municipality. Unpublished thesis. University of the Witwatersrand. Available online at http://wiredspace.wits.ac.za/handle/10539/8231 [Accessed on 4 January 2019].

Noi, C. and Ciroth, A. 2018. Environmental and social pressures in mining. Results from a sustainable hotspots screening. *Resources*, 1-21.

Odell, C.J., Scoble, M. and Recharte Bullard, J. 2011. Improving Socio-Environmental Outcomes at Andean Mines. *International Journal of Mining, Reclamation and Environment,* 25(2): 133-151.

Otchere, F.A., Veiga, M.M., Hinton, J.J., Farias, R.A. and Hamaguchi, R. 2004. Transforming open mining pits into fish farms: Moving towards sustainability. *Natural Resources Forum,* 28(3):216-223.

Owen, J.R., Kemp, D. 2013. Social licence and mining: A critical perspective. *Resources Policy*. 38(1):29-35. https://doi.org/10.1016/j.resourpol.2012.06.016.

Palogos, I., Galetakis, M., Roumpos, C. and Pavloudakis, F. 2017. Selection of optimal land uses for the reclamation of surface mines by using evolutionary algorithms. *Int. J. Min. Sci. Technol*. 27:491-498.

Parviainen, A. 2012. Evolution of Sulfide Oxidation and Attenuation Mechanisms Controlling Acid Mine Drainage in Decommissioned Low-Sulfide Taizlings. Ph.D. Thesis, Aalto University, Greater Helsinki, Finland, p. 162. Available online at http://lib.tkk.fi/Diss/2012/isbn9789526047423/isbn9789526047423.pdf [Accessed on 04 September 2019].

Pearman, G. 2009. 101-Things to do with a Hole in the Ground. Post-Mining Alliance, Eden Project. Cornwall, United Kingdom.

Pepper, M., Roche, C.P. and Mudd, G.M. 2014. Mining legacies Understanding life-of-mine across time and space. In Proceedings of the Life-of-Mine Conference 2014, Brisbane, Australia, 16–18 July 2014; pp. 1449–1466.

Pereira, R., Barbosa, S. and Carvalho, F.P. 2014. Uranium mining in Portugal: A review of the environmental legacies of the largest mines and environmental and human health impacts. *Environ. Geochem. Health*. 36:85-301.

Petts, J. 1999a. Environmental impact assessment—overview of purpose and practice. In: Petts J, editor. Handbook of environmental impact assessment, vol. 1. Oxford: Blackwell; p. 3 – 11.

Petts, J. 1999b. Environmental impact assessment versus other environmental management decision tools. In: Petts J, editor. Handbook of environmental impact assessment, vol. 2. Oxford: Blackwell; p. 1 – 9.

Petts, J. 1999c. Introduction to environmental impact assessment in practice: fulfilled potential or wasted opportunity? In: Petts J, editor. Handbook of environmental impact assessment, vol. 2. Oxford: Blackwell; p. 33 – 59.

Polygon Environmental Planning. 2012. Environmental Impact Assessment Report. Township Establishment and Associated Infrastructure on Portion 2 of Farm Cooyong 1100-LS, Haenertsburg, Limpopo Province.

Pósleman, C.S and Sallan, J.M. (2019). Social license to operate in the mining industry: the case of Peru, Impact Assessment and Project Appraisal, 37(6):480-490.DOI:10.1080/14615517.2019.1585142.

Prinsloo, J. and Marais, J. 2015. Catastrophe looms as mines are left in the dumps. Available online at: http://www.bdlive.co.za/businesstimes/2014/09/07/catastrophe-looms-as-minesare-left-in-the-dumps. [Accessed on 21 August 2019].

Ranangen, H. and Lindman, A. 2017. A path towards sustainability for the Nordic mining industry. *Journal of Cleaner Prod*uction 151, 43–52.

Redondo-Vega, J.M., Gómez-Villar, A., Santos-González, J., González-Gutiérrez, R.B. and Álvarez-Martinez, J. 2017. Changes in land use due to mining in the north-western mountains of Spain during the previous 50 years. *Catena*. 149:844-856.

Rigina, O. 2002. Environmental impact assessment of the mining and concentration activities in the Kola Peninsula, Russia by multidate remote sensing. *Environ. Monit. Assess*. 75:11-31.

Robertson, A. and Shaw, S. 2006. Mine Closure, Info-mine e-book. Available online at http://www.infomine.com/library/publications/docs/E-Book%2002%20Mine%20Closure.pdf. [Accessed on 20 September 2019].

Robinson, B.H., Anderson, C.W. and Dickinson, N.M. 2015. Phytoextraction: Where's the action. *J. Geochem. Explor.* 151:34-40.

Rogerson, C.M. 2014. Reframing Place-Based Economic Development in South Africa: The Example of Local Economic Development. *Bulletin of Geography*. Socio-economic Series, (No 24). 8/6/15: 203-218.

Sánchez, L.E., Silva-Sánchez, S.S. and Neri, A.C. 2014. Guide for mine closure planning. Lago Sul: Instituto Brasileiro de Mineração.

Sanchez, A., Mejia, M. and Bueno, N. 2009. Understanding residents' attitudes toward the development of industrial tourism in a former mining community. *Journal of Travel Research*, 473:373-387.

Sandlos, J. and Keeling, A. 2016. Aboriginal communities, traditional knowledge, and the environmental legacies of extractive development in Canada. *Ext. Ind. Soc*. 3, 278–287.

Saunders, M., Lewis, P. and Thornhill, A. 2000. *Research methods for business students*. Edinburg: Pearson Education.

SBP – Strategic Business Partner, 2005. Main report: counting the cost of red tape for business in South Africa. Johannesburg: Strategic Business Partnership.

Sheoran, V., Sheoran, A.S. and Poonia, P. 2010. Soil reclamation of abandoned mine land by revegetation: A review. *Int. J. Soil Sediment Water*. 3:13.

Shih, H.S., Shyur, H.J. and Lee, E.S. 2007. An extension of TOPSIS for group decision making. *Mathematical and Computer Modelling*, 45:801-813Sikaundi, G. 2013. Copper mining industry in Zambia: environmental challenges. Available at http://unstats.un.org/unsd/environment. [Accessed 22 August 2019].

Slingerland, N. and Wilson, G.W. 2015. End Land Use as a Guide for Integrated Mine Planning and Closure Design; Mine Closure: Vancouver, BC, Canada. Available online at https://www.researchgate.net/profile/Neeltje_Slingerland/publication/304626811_End_land_use_as_a_guide_for_integrated_mine_planning_and_closure_design/links/57c5b69f08ae0a6b0dc8d31f.pdf. [Accessed on 04 September 2019].

Soltanmohammadi, H, Osanloo, M. and Aghajani, A, 2008a. Deriving preference order of post-mining land-uses through MLSA framework: application of an outranking technique, *Environ Geol*, DOI 10.1007/s00254-008-1563-y, Springer Verlag.

Soltanmohammadi, H., Osanloo, M., Rezai, B. and Aghajani. 2008b. Achieving to some outranking relationships between post mining land uses through mined land suitability analysis. *International Journal of Environmental Science and Technology*, 5(4):535-546.

Soltanmohammadi, H., Osanloo, M. and Bazzazi, A. 2009. Deriving preference order of post-mining land-uses through MLSA framework: application of an outranking technique. *Environmental Geology*, 58(4):877-888.

Soltanmohammadi, H., Osanloo, M. and Bazzazi, A.A. 2010. An analytical approach with a reliable logic and a ranking policy for post-mining land use determination. Land Use Policy 27. pp. 364-372.

Sombroek, W. and Carvalho de Souza, A. 2000. Macro- and micro ecological-economic zoning in the Amazon Region – history, first results, lessons learnt and research needs. German-Brazil Workshop on Neotropical Ecosystems. Hamburg-September 3-8.

Soni, A., Mishra, B. and Singh, S. 2014. Pit lakes as an end use of mining: A review. *J. Min. Environ*. 5:99-111.

Sonja, K. 2017. Sustainable Post-Mining Land Use: Are Closed Metal Mines Abandoned or Re-Used Space? *Sustainability.* 9 (1705):2-18.

South Africa. 1989. *Environment Conservation Act, 73 of 1989*, Pretoria: Government Printer.

South Africa. 1998. *National Environmental Management Act, 107 of 1998*, Pretoria: Government Printer.

South Africa. 2010. *Environmental Assessment Regulations*, No. R.543, 544, 545, 546 and 547, Government Gazette, 33306, 18 June 2010 Pretoria: Government Printer.

South African Chamber of Mines. 2007. Guideline for the rehabilitation of mined land.

Stacey, J., Naude, A., Hermanus, M. and Frankel, P. 2010. The socio-economic aspects of mine closure and sustainable development: literature overview and lessons for the socio-economic aspects of closure - Report 1. *Journal of the Southern African Institute of Mining and Metallurgy*, 110:379-394.

Starke, L. 2016. *Breaking new ground: mining, minerals, and sustainable development.* Routledge.

Statistics South Africa (Stats SA). 2012. National Accounts: Mineral Accounts for South Africa: 1980-2009, Pretoria: Stats SA.

Stefano, M. and Paolo, S. 2016. Abandoned quarries and geotourism: An opportunity for the Salento quarry district (Apulia, Southern Italy). *Geoheritage*, 1–15.

Steyn, L. 2018. *What will happen to Lonmin's 13 000 workers?* Available online at Financial Mail: https://www.businesslive.co.za/fm/money-and-investing/2018-11-22-what-will-happen-to-lonmins-13000-workers/. [Accessed 4 January 2019].

Strydom, M. 2017. The National Environmental Management Act: 2017 Amendments to the Environmental Impact Assessment Regulations. *Bowmans Law Firm Publication*. Available at https://www.bowmanslaw.com/insights/environmental-law/national-environmental-management-act-2017-amendments-environmental-impact-assessment-regulations/. [Accessed on 23 August 2019].

Swanepoel, E. 2008. Once described as ‘quite frightening’, state now claims EIA backlog will be cleared this year. *Engineering News*, available online at http://www.engineeri ngnews.co.za/print_version.php?a_id¼139675 [Accessed 26 September 2019]

Sweeting A, Clark A. 2000. Lightening the lode: a guide to responsible large-scale mining. Washington (DC): Conservation International.

Tuovinen, H., Pohjolainen, E., Vesterbacka, D., Kaksonen, K., Virkanen, J., Solatie, D., Lehto, J. and Read, D. 2016. Release of radionuclides from waste rock and tailings at a former pilot uranium mine in eastern Finland. *Boreal Environ. Res.* 21:471-480.

Thompson, J. 2011. Waihi’s Golden Legacy: Planning for the Future. SRK Denver, Colorado, May 2011. 17.

United Nations (UN). 2002. Plan of Implementation of the World Summit on Sustainable Development, New York: UN.

United Nations Economic Commission for Africa, and African Union. 2011. AU conference of Ministers responsible for mineral resources development: minerals and Africa’s development-an overview of the report of the international study group on Africa’s mineral regimes. Addis Ababa: UNECA.

Van Heerden, JJ. 2016. Sustainable mining communities post mine closure: Critical reflection on roles and responsibilities of stakeholders towards local economic development in the City of Matlosana. *Unpublished Thesis*. Stellenbosch: University of Stellenbosch.

Van Schalkwyk, M. 2006. *NEMA EIA Regulations: environmental protection: quicker, faster and better,* Speech given at the launch of the National Environmental Management Act EIA regulations on 19 April 2006. Pretoria. Available online at http://www.environment.gov.za/News Media/MedStat/2006apr19_1/19042006.htm [Accessed 26 September 2019].

Van Zyl, D.M., Sassoon, C., Digby, A.M., Fleury, S. and Kyeyune, E. 2002. Mining for the future: Report of the large volume waste component of mining, minerals and sustainable development project. Available online fromhttp://www.iied.org/mmsd/activities/large_volume_waste.html [Accessed 4 January 2019].

Venkata, R. R. 2007. Decision Making in the Manufacturing Environment-Using Graph Theory and Fuzzy Multiple Attribute Decision Making Methods. *Springer Series in Advanced Manufacturing* ISSN 1860-5168:3-49.

Venkateswarlu, K., Nirola, R., Kuppusamy, S., Thavamani, P., Naidu, R. and Megharaj, M. 2016. Abandoned metalliferous mines: Ecological impacts and potential approaches for reclamation. *Rev. Environ. Sci. Bio/Technol*. 15,327–354.

Watkins, J. 2012. *Theses/Dissertations/Research Reports: A practical guide for students to the preparation of written presentations of academic research.* Gordons Bay: J.A. Watkins.

Weaver, A. Rossouw, N. and Grobler, D. 1999. Scoping and issues focused environmental impact assessment in South Africa. *African Journal of Environmental Assessment and Management,* 1(1):1-11.

Wessman, H. and Salmi, O. 2014. Water and society: Mutual challenges for eco-efficient and socially acceptable mining in Finland. Research paper for *Journal of Cleaner Production and Special volume for Mining*.

Wirth, P., Černič-Mali, B. and Fischer, W. 2012. Post-Mining Regions in Central Europe-Problems, Potentials, Possibilities; Oekom, München: Munich, Germany.

Wong, MH. 2003. Ecological restoration of mine degraded soils, with emphasis on metal contaminated soils. *Chemosphere*. 50:775–780.

Wood, C. 2003. Environmental Impact Assessment: A Comparative Review. 2nd Edition, Longman, Harlow.

World Bank. 2002. It's not over when it's over: Mine closure around the world. *Mining and Development series*. NY: World Bank and International Finance Corporation.

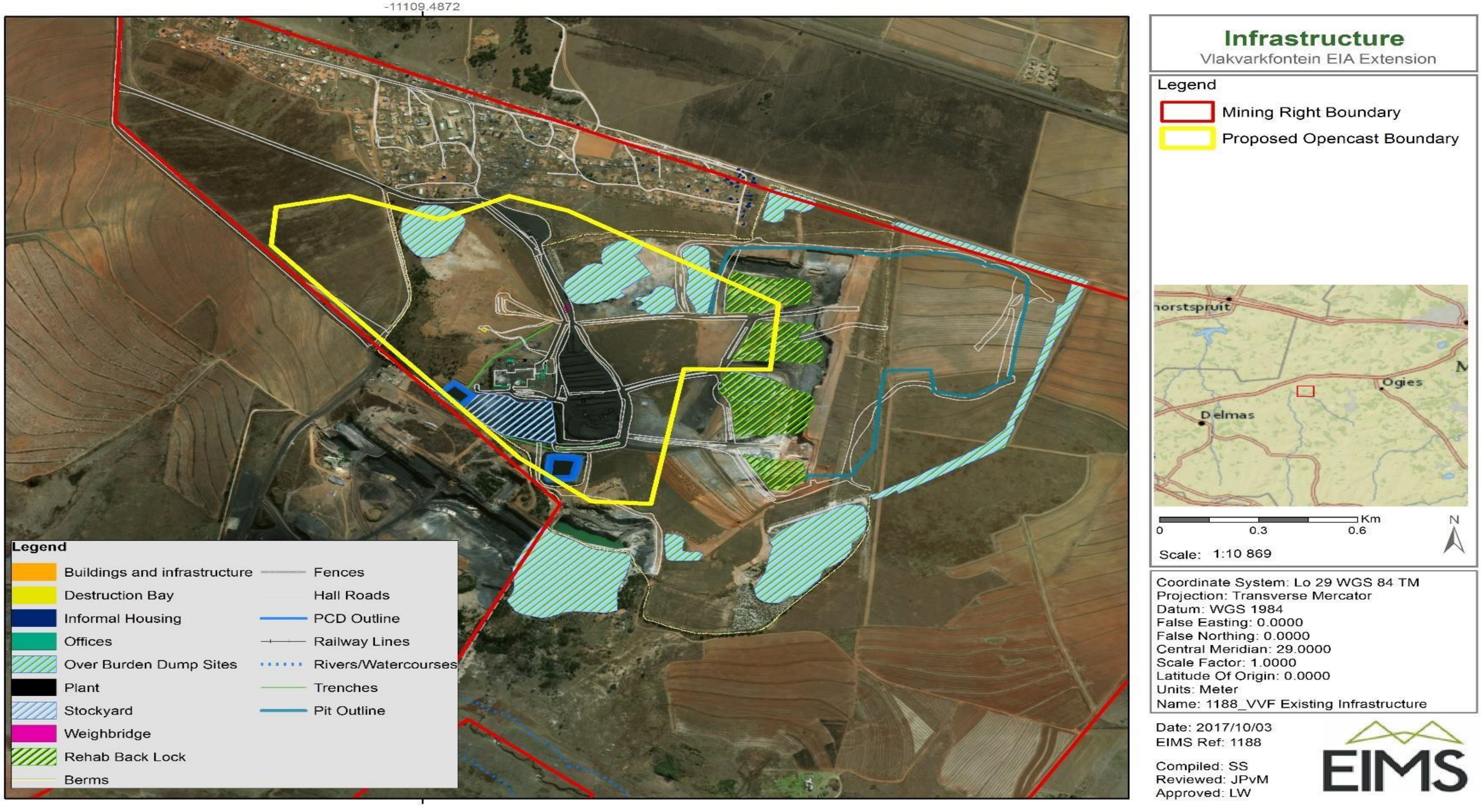
Zavadskas, E.K. and Antucheviciene, J. 2006. Development of an indicator model and ranking of sustainable revitalization alternatives of derelict property: a Lithuanian case study. *Sustainable Development*, 14:287-299.

Zhang, J., Rao, Y., Geng, Y., Fu, M. and Prishchepov, A.V. 2017. A novel understanding of land use characteristics caused by mining activities: A case study of Wu'an, China. *Ecol. Eng*. 99:54-69.

Zhao, A. and Tang, A. 2015. Land subsidence risk assessment and protection in mined-out regions. *PIAHS*. 372,145.

APPENDIX 1. OPENCAST MINE AT VLAKVARKFONTEIN COAL MINE. Source: EIMS, (2017).

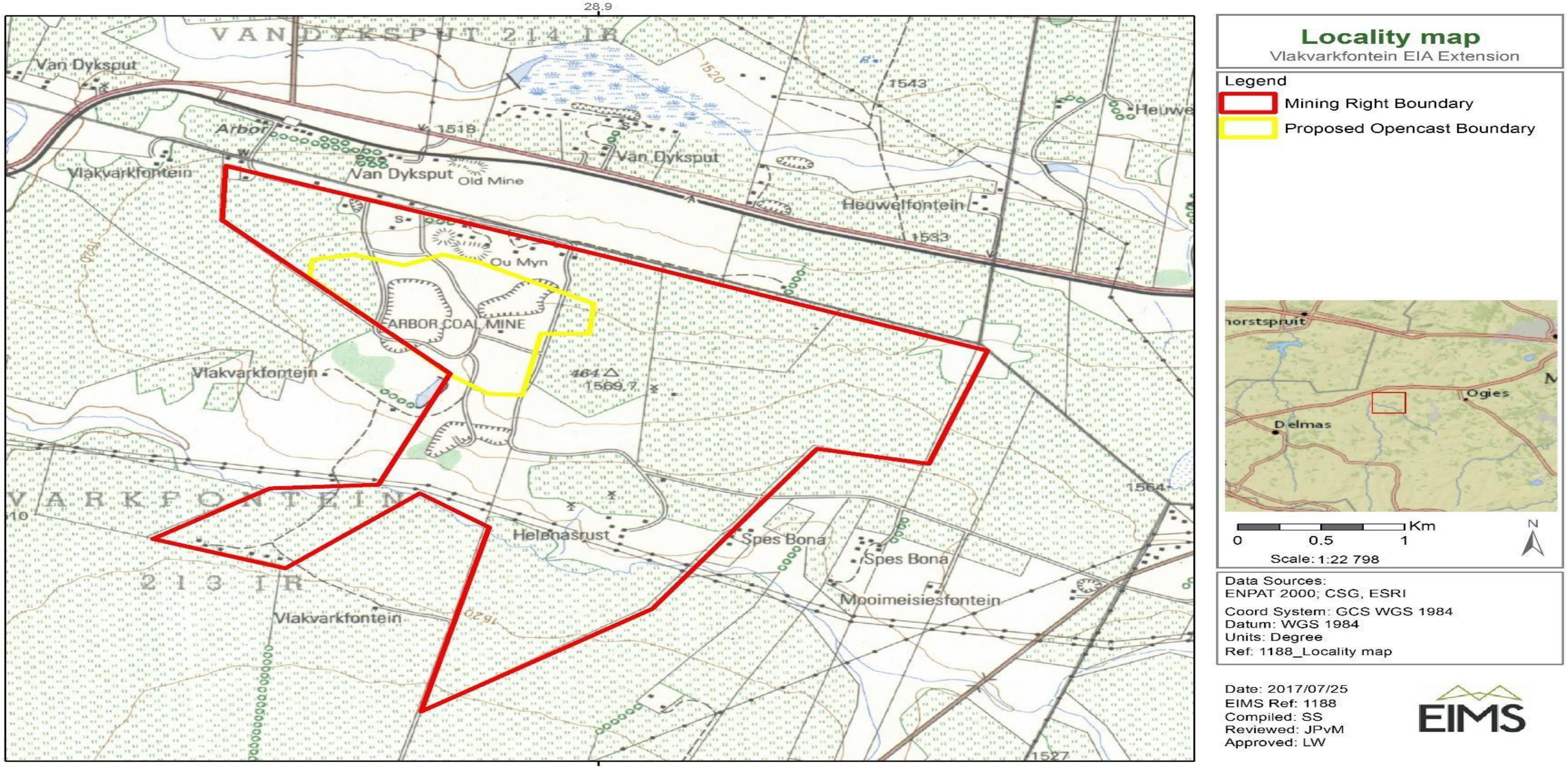
APPENDIX 2. INFRASTRUCTURE MAP OF VLAKVARKFONTEIN COAL MINE. Source: EIMS, (2017)



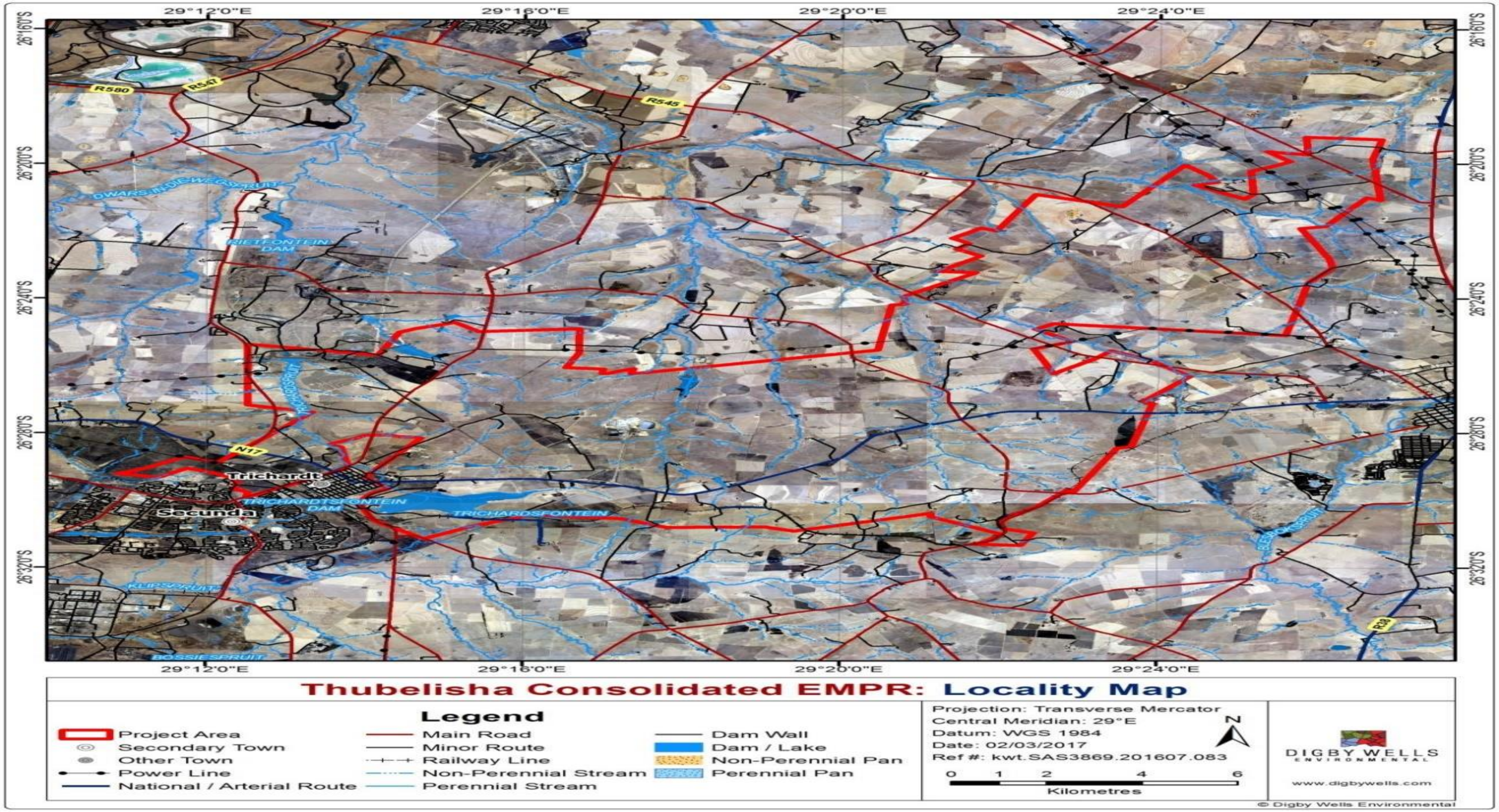
APPENDIX 3. LIFE OF MINE (LOM) VLAKVARKFONTEIN PRODUCTION SCHEDULE – ALL MATERIAL TYPES AND COAL. SOURCE: EIMS, (2017).

PRODUCTION WEST & EAST	Unit	FY2018	FY2019	FY2020	FY2021	FY2022	FY2023	FY2024	FY2025	TOTAL
TOPSOIL	bcm	23 523	21 853	267 956	217 553	144 459	105 497	68 737	-	**849 578**
SOFTS	bcm	114 733	176 064	1 426 536	1 101 710	841 368	908 844	740 118	-	**5 309 374**
HARDS	bcm	947 649	1 387 567	840 769	1 097 423	1 423 833	1 395 319	914 183	-	**8 006 742**
S4N COAL	romt	110 289	41 826	-	23 784	63 936	167 173	143 039	-	**550 046**
S4S COAL	romt	295 248	224 340	-	89 086	115 228	401 913	356 248	-	**1 482 063**
S4PIL COAL	romt	-	-	-	348 964	468 533	56 407	-	-	**873 904**
S2 PARTING	bcm	990 021	1 525 892	685 064	1 208 343	878 735	775 311	1 075 590	62 156	**7 201 112**
S2S COAL	romt	644 752	1 142 064	1 112 123	373 651	185 625	391 387	604 625	342 809	**4 797 035**
S2N COAL	romt	-	-	573 695	127 859	45 744	145 716	117 807	69 797	**1 080 618**
S2PIL COAL	romt	-	-	147 876	1 048 300	1 270 614	806 293	164 127	3 592	**3 440 801**
TOTAL WASTE	bcm	2 075 926	3 111 376	3 220 326	3 625 028	3 288 395	3 184 971	2 798 628	62 156	**21 366 807**
TOTAL COAL	romt	1 050 289	1 408 230	1 833 694	2 011 643	2 149 679	1 968 889	1 385 846	416 197	**12 224 467**
TOTAL STRIP RATIO	bcm/romt	1,98	2,21	1,76	1,80	1,53	1,62	2,02	0,15	**1,75**

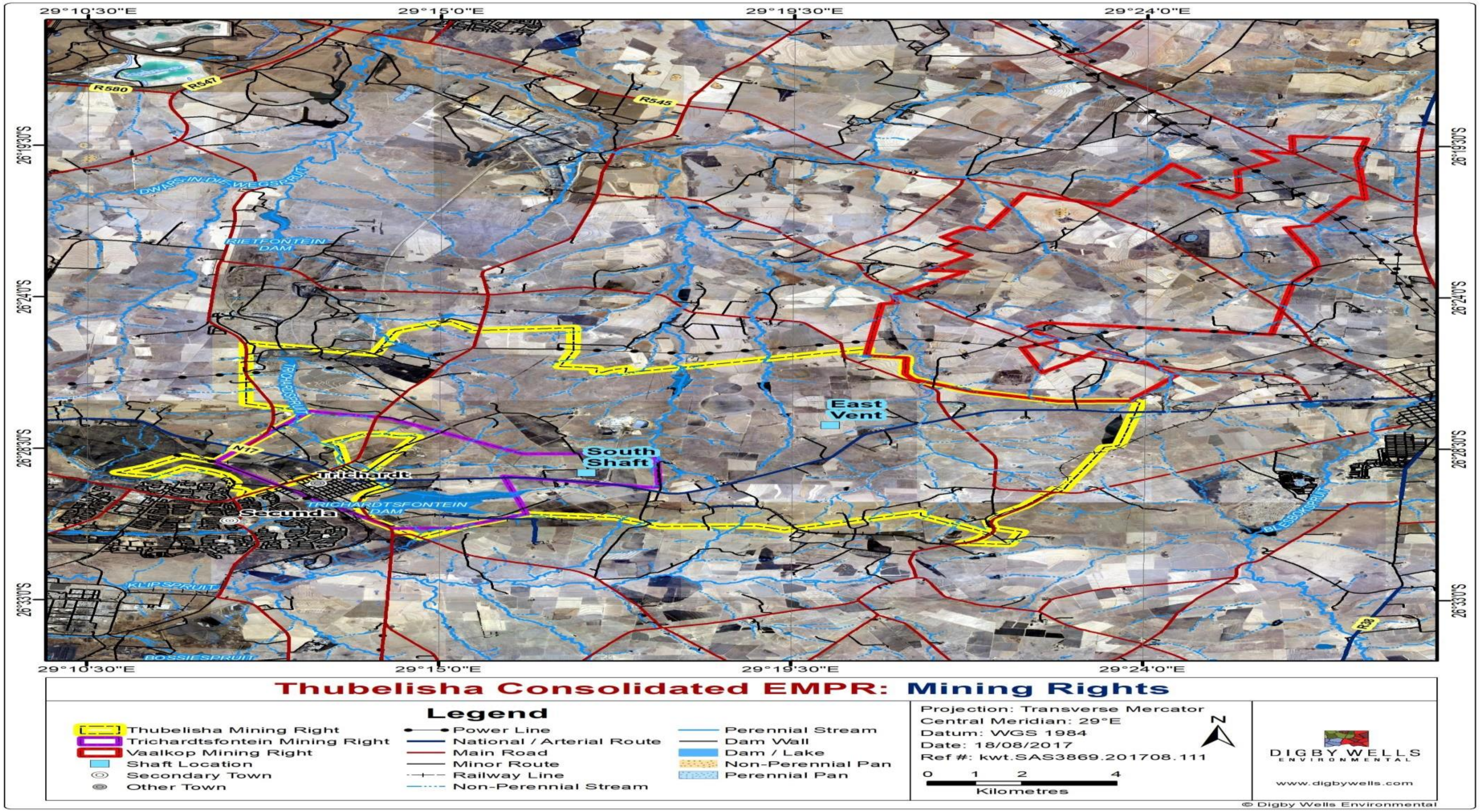
APPENDIX 4. TOPOGRAPHICAL LOCALITY MAP. Source: EIMS, (2017)



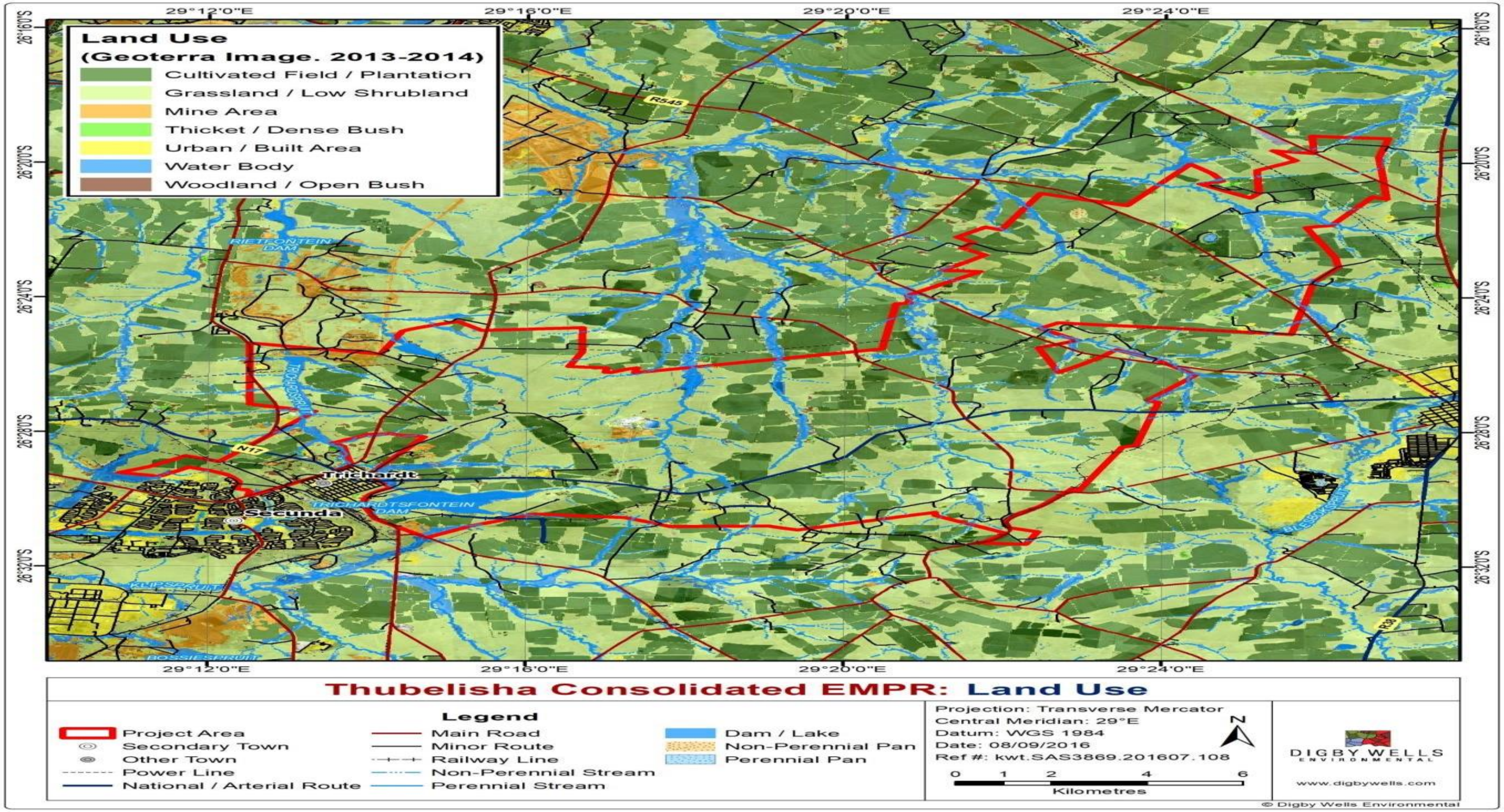
APPENDIX 5. LOCAL SETTING OF THE PROJECT SITE. Source: Digby Wells, (2017).



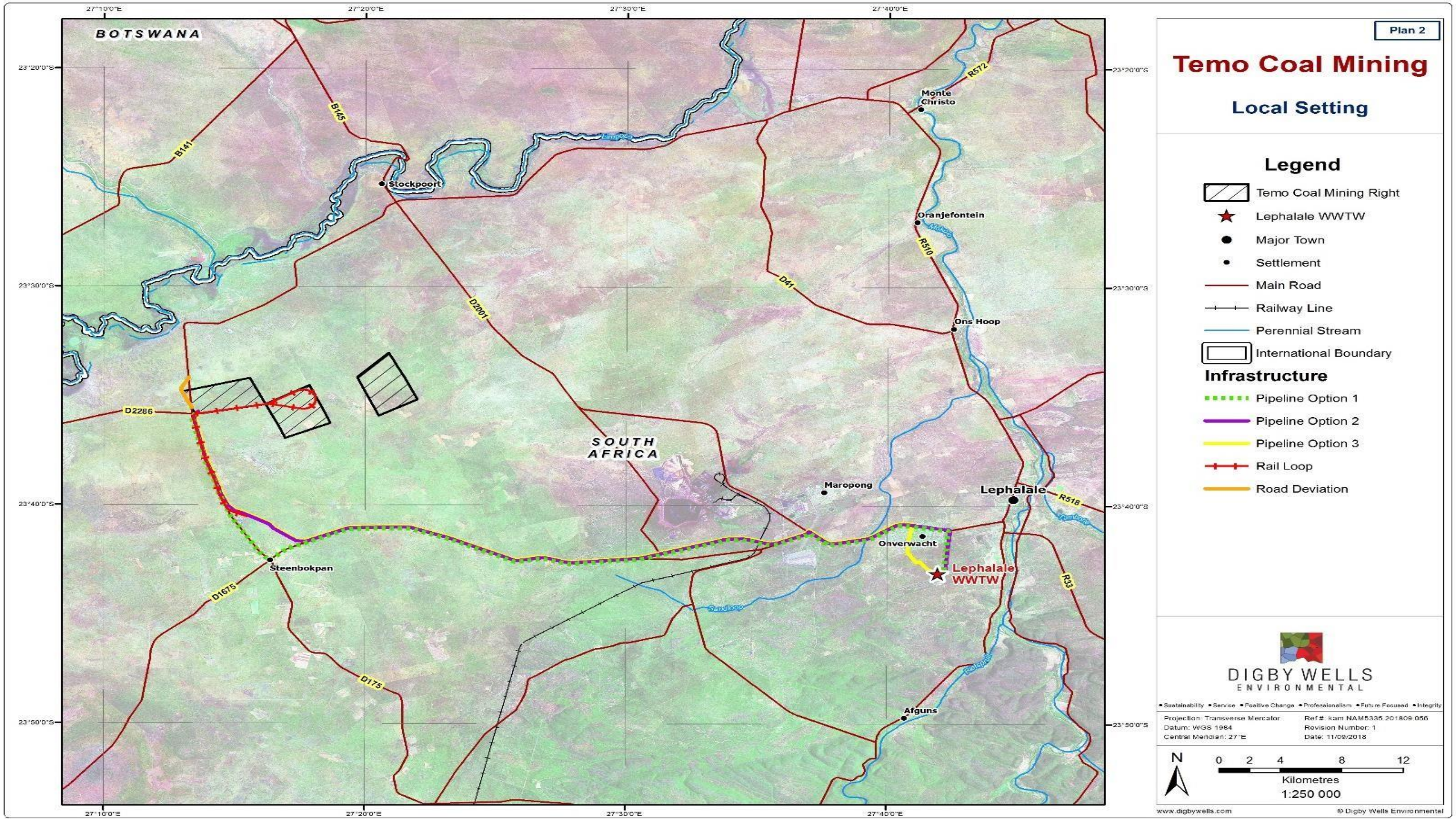
APPENDIX 6. MINING RIGHT BOUNDARIES AND PROPOSED INFRASTRUCTURE LAYOUT. SOURCE: Digby Wells, 2017.



APPENDIX 7. LAND USE FOOTPRINT. Source: Digby Wells, 2017.



APPENDIX 8. THE MINING RIGHT LOCAL SETTING. Source: Digby Wells, (2019)



APPENDIX 9. ANALYSIS OF THE MINING ENVIRONMENTAL IMPACT ASSESSMENT REPORTS

A comparative analysis of EIA reports

Comparative analysis of the mining EIAs			
	EIA 1 Vlakvarkfontein Coal Mine extension, associated infrastructure, and amendments to existing licence conditions.	**EIA 2** Rehabilitation, decommissioning and mine closure plan for the Thubelisha, Trichardtsfontein, and Vaalkop mining right areas.	**EIA 3** Rail loop, road diversion, and project associated with the Temo Coal Mine, Limpopo Province.
Parties involved			
-Applicant	Ntshovelo Mining Resources (Pty) Ltd (Ntshovelo) a subsidiary of Mbuyelo Coal (Pty) Ltd	Sasol Mining (Pty) Ltd	Temo Coal (Pty) Ltd
-Environmental assessment practitioner (EAP)	Geo Soil and Water CC	Digby Wells Environmental (Pty) Limited	Digby Wells Environmental (Pty) Limited

-Competent authority (CA)	Department of Mineral Resources, Republic of South Africa	Department of Mineral Resources, Republic of South Africa	Department of Mineral Resources, Republic of South Africa
-Interested and affected parties (I&APs)	Mpumalanga Department of Agriculture, Rural Development, Land and Environmental Affairs. Other regulatory authorities, landowners, communities, and special interest groups.	Govan Mbeki Local Municipality (GMLM) within the Gert Sibande District (GSDM). Other regulatory authorities, landowners, communities, and special interest groups.	Land owners/occupiers, communities, Limpopo District Municipality and other relevant government authorities, non-governmental organisations (NGOs), and business enterprises.

Major Environmental -Risks	**Air quality**: Blasting, cracks in houses, air and noise pollution. Air pollution may arise because of particulates entering the atmosphere. These dust particulates are from haul roads, and on overburden stockpiles.		Particulate matter emissions, and noise pollution.
	Biodiversity: Loss/disturbance of topsoil. There is also evidence of overgrazing and unrehabilitated mining, leading to unlawful re-mining. Exposure of this area to erosion has contributed to soil erosion and contamination of soils.	The project area encompasses large wetland areas totalling 5,278 ha. Approximately 3,053 ha of the wetlands will potentially be affected. Irreversible changes to abundance/biomass in affected area. Loss of ecological function with minimal recovery prospects	Direct loss of 79 ha of natural habitat. Loss and/or compromised ecological services provided by areas of high sensitivity. Potential loss of faunal species because of habitat destruction and road kills. Soil erosion and soil compaction leading to loss of topsoil resources and alteration of ecological services
	There are other mines, grazing and cultivated land, as well as an Eskom power station upstream of the proposed mining area.	The impact of subsidence and/or decant would be high if those events were to occur.	

	Removal of threatened and protected species; loss/destruction of natural habitat; displacement of faunal species; flora direct and indirect mortality; fauna direct and indirect mortality.		
	Water quality: Alteration of hydrological regime; three streams near Vlakvarkfontein are at risk of potentially being affected by the mining activities. These include the Wilge River, Klipspruit, and Kromdraaispruit.	The landscape will have an impact on groundwater due to decant being released at some point as the underground mine voids naturally fill up with water once dewatering stops. Consequently, the water quality may be compromised. The proposed project is likely to continue to contribute to these cumulative impact to wetland resources in the Mpumalanga Province region.	Mining runoff or contamination. Hydrocarbon spills from vehicles, heavy machinery, hazardous materials or waste storage facilities, and leaks from the water pipeline.

	Surface water quality in catchments within which the Vlakvarkfontein Coal Mine operates has been affected by current and previous uses which includes, agricultural practices (cultivation and grazing), mining (current and defunct mining), and power generation activities.		Loss of catchment yield and surface water recharge. Bed and channel disturbances.
		The project has potential to adversely impact on natural wetlands, altering functioning of these systems and compromising their ability to provide ecosystem services.	
-Positive impacts	Environmental conservation awareness.	Environmental conservation awareness.	Environmental conservation awareness.

-Improvements	Integration of environmental issues with municipalities' strategic long-term planning.	Monitoring of activities through all phases to ensure that their impact is remediated as soon as possible; thus, preventing a long-term residual impact on the system that will compromise wetland functionality.	Restriction/minimisation of the duration of high-impact activities.
Major socio-economic issues			
-Risks	Safety/security (i.e., access to properties, theft, and fire hazards, etc).		
	Disturbance and destruction of archaeological sites.		Livestock grazing pressure.

	Disturbance and destruction of historical buildings or structures; Disturbance/destruction of fossils.	Removal of infrastructure, loss of habitat and agricultural resource.	The presence of an outside workforce may expose the vulnerability and susceptibility of local communities to social pathologies, such as drug and/or alcohol abuse, increased incidence of crime, and domestic violence.
	Disturbance/destruction of graves (marked and unmarked), and cemeteries.		
-Positive impacts	Employment, infrastructural development, and revenue.	Employment, promotion of local suppliers and businesses, infrastructure development, and revenue.	Employment and businesses opportunities for local suppliers of goods and services. Support domestic coal demand to sustain and increase energy security which in turn promotes economic development.

-Improvements	Skills development programmes.	Engagement with stakeholders and employees regarding closure-related aspects and formulisation of a retrenchment and downscaling policy demonstrating training initiatives and skills development.	Development of code of conduct for construction workers and sensitising them to abide by it so that their behaviour and engagement with local communities does not compromise either party.
		Progress tracked against the training matric of each employee assisting with the upskilling of employees, which would enable individuals to seek alternative employment at the time of mine closure.	Exploring opportunities for collaboration with the police regarding safety and security issues relating to project activities, in general, and any concerns about local contractors.

APPENDIX 10. SYSTEMIC APPROACH PERFORMANCE OF EIA REPORTS

Performance of the EIA systems measured by systemic evaluation criteria. This table summarises the comparison and evaluation of the three EIA reports using systemic evaluation criteria. Distinctive attributes of each EIA report are highlighted.

	EIA 1	EIA 2	EIA 3	Synthesis of performance
Is the EIA report based on specific and clear legal provisions?	Yes	Yes	Yes	
Are legal provisions or specifications on the deadline available to the EIA authority in order to issue professional opinions over the course of the various stages of the EIA process?	Yes	Yes	Yes	Basic assessment – acknowledge receipt (if application is in order) or reject application (if not in order). Basic assessment decision, i.e., accepted or refused, 30 days.
Are there provisions on the deadlines for presenting appeals against a decision?	Yes	Yes	Yes	The appeal must be presented within a maximum of 30 days counted from the date of presentation of the notice of the intention to file an appeal.
Is there a competent EIA authority?	Yes	Yes	Yes	DEAT is responsible for evaluating projects of national importance (i.e., projects that cross provincial or national boundaries). The

				environmental departments of the various provincial governments are responsible for evaluating applications that have been submitted in terms of the EIA regulations.
EIA PROCESS				
Are the details of the EIA report defined in the legislation?	Yes	Yes	Yes	The content of the EIA report is described in detail in the EIA legislation.
Are there requirements for drawing up environmental management plans? If so, what are the details.	Yes	Yes	Yes	According to Decree No. 51/2004, a supervision and monitoring programme of the positive and negative impacts must be drawn up, indicating the factors and parameters to be taken into consideration.
Are there requirements for drawing up a monitoring plan? If so, what should be included within this plan	Yes	Yes	Yes	According to Decree No. 51/2004, a supervision and monitoring programme of the positive and negative impact must be drawn up, indicating the factors and parameters to be taken into consideration.
Is the EIA report made available for public consultation? If so, how does this take place?	Yes	Yes	Yes	The public consolidation process begins with prior disclosure of a non-technical summary of the environmental impact assessment, specifying the key effects that the project may generate in the environment. In particular, use of natural resources, emission of polluting agents, creation of disturbances (ranging from intensity of lighting/heat to noise and smells) or elimination of residues, identifying the preventive methods used in order to evaluate and diminish the effects on

				the environment, together with the project's impact on the socioeconomic environment. Disclosure of these elements must respect industrial confidentiality and observe legal norms protecting non-patented technical knowledge. In the framework of the public consultation, statements and complaints related to the project that have been presented, will be considered and appraised.
Is the EIA report altered in light of the comments received during the public consultation?	N/A	N/A	N/A	No legal provisions exist for this purpose. However, based on existing practice, the minister responsible for the environment will decide on the project's environmental acceptability, based on conclusions reached during the revision process.

APPENDIX 11. A summary of issues and comments by I&APs. Source: Adapted from Vlakvarkfontein Coal Mine extension EIA report (EIMS, 2018).

I&APs' issues and concerns	**Themes**	**Concerns about Post-mining land use**
Concerned about what happens to them if the house they are living in is already owned by someone who was previously moved. Are occupiers included in the potential move or will they be excluded from the opportunity to have a permanent place to live.	Relocation Housing	None: This could be that at the time, the concern was about meeting their basic needs.
Concerns regarding the letter that community members sent to the mine on 1 August 2017. The community was expecting a response by the 16 August 2017, but none was provided. *Concerns around blasting and the effects it has on their houses. Many houses have already been damaged due to blasting and now they will be damaged more.* *If they move, they will be moving to a single stand, whereas they have invested money into building their own space.*	Responsiveness Blasting (noise pollution) Relocation Housing	None
Was told she is being moved. Concerns around blasting and that the negatives of the extension will outweigh the positives. However, this community member did not elaborate further on what the "negatives and positives" are.	Relocation Benefits	None

Not allowed heating in houses. It gets very cold. They are not given coal for heating or cooking, and they are not allowed to buy coal.	Heating Access to coal	None
A community member's issue involved the fact that the house did not have electricity.	Electricity	None
Complaints about the mine not responding to their concerns. *The mine made numerous promises when it initially started, and nothing has been done.* *Concerns about access to water; they have to walk down the road to get water. There have been talks about the mine installing a water system. Would like to know if it is still happening.* *They built a relationship with their contact at the mine who has moved to Manungu so they now have to start from scratch with a new person who doesn't know the issues they have been discussing.*	Social engagement Water	None
Dust and cracking houses concern. The water suppression truck only comes at noon and sometimes he doesn't see it. *Traffic impact on the livestock. Livestock is injured or killed because the drivers don't adhere to the speed limit. Focus groups to be held as the youth do not give everyone a chance to speak.*	Dust Cracking houses Traffic Animals at risk Focus group meeting	None
Was previously moved but the new house does not have the gardens he previously had. *The new houses are basically just structures with no facilities, e.g., no water connections.*	Social dislocation	None

APPLICATION FORM

Please Note:
Any person planning to undertake research in the Faculty of Engineering and the Built Environment (EBE) at the University of Cape Town is required to complete this form **before** collecting or analysing data. The objective of submitting this application *prior* to embarking on research is to ensure that the highest ethical standards in research, conducted under the auspices of the EBE Faculty, are met. Please ensure that you have read, and understood the **EBE Ethics in Research Handbook** (available from the UCT EBE, Research Ethics website) prior to completing this application form: http://www.ebe.uct.ac.za/ebe/research/ethics1

APPLICANT'S DETAILS		
Name of principal researcher, student or external applicant		Prince Destiny Ugo
Department		Chemical Engineering
Preferred email address of applicant:		Ugxdes001@myuct.ac.za
If Student	Your Degree: e.g., MSc, PhD, etc.	MPhil
	Credit Value of Research: e.g., 60/120/180/360 etc.	60/120
	Name of Supervisor (if supervised):	Professor Harro Von Blottnitz
If this is a researchcontract, indicate the source of funding/sponsorship		NRF
Project Title		Sustainability assessment of post-mining land use planning

I hereby undertake to carry out my research in such a way that:

- there is no apparent legal objection to the nature or the method of research; and
- the research will not compromise staff or students or the other responsibilities of the University;
- the stated objective will be achieved, and the findings will have a high degree of validity;
- limitations and alternative interpretations will be considered;
- the findings could be subject to peer review and publicly available; and
- I will comply with the conventions of copyright and avoid any practice that would constitute plagiarism.

SIGNED BY	Full name	Signature	Date
Principal Researcher/ Student/External applicant	Prince Destiny Ugo	Signed by candidate	**08 Aug 2019**

APPLICATION SUPPORTED BY	Full name	Signature	Date
Supervisor (where applicable)	Harro von Blottnitz		**15 Aug 2019**
HOD (or delegated nominee) Final authority for all applicants who have answered NO to all questions in Section1; and for all Undergraduateresearch (Including Honours).	Click here to enter text. Tracey van Heerden		Click here to enter a date. 12/11/2019
Chair : Faculty EIR Committee For applicants other than undergraduate students who have answered YES to any of the above questions.			

Signatures Removed