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Framework to guide mine-related land use planning towards optimisation of the coal mining rehabilitated landscape

Masters project dissertation for submission for a degree at the University of Pretoria

by

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Declaration

By submitting this research assignment electronically, I, Raina Hattingh, declare that the entirety of the work contained therein is my own, original work, that I am the owner of the copyright thereof (unless to the extent explicitly otherwise stated) and that I have not previously, in its entirety or in part, submitted it for obtaining any qualification.

Raina Hattingh October 2017

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The focus of this study was defined according to my interest in the possibilities for improved use of the post-mining landscape. Throughout the literature review, interviews and general 'knowledge searching' as part of this study, various colleagues, industry role players and peers formed an integral part in shaping the direction of thinking and ultimate outcome of this research. Hard questions were raised, my personal opinions were challenged and, in the end, I learnt a significant amount about both the theoretical and practical aspects of improving the functionality of mining-disturbed landscapes.

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Preamble

"*If we design to engage the public; if we interpret these [mine] sites in ways that allow understanding; if we admit that good science is always necessary but sometimes not sufficient; if we use public history to inform the future, we create the opportunity for much broader public participation in reclamation issues. We may even do some small things to help rekindle a reason for pride in coal*" (Comp, 2013).

A global awareness of the anthropogenic pressures on the earth has resulted in the incorporation of sustainable development principles into international legislation, global governance structures and individual companies' operating procedures. Mining, with its significant environmental and social impacts, appears to have embraced this concept in its rehabilitation, land use and closure planning.

The considerable biological and physical impacts on water, air, habitats and landscape arising from mining and the waste it produces appear to be well understood. Current ecological rehabilitation focus is on protecting and improving ecosystem goods and services of rehabilitated landscapes, thereby creating and improving ecological functionality. More recently, and as driven by global community needs and demands, the focus of mining rehabilitation and closure planning is turning to social (community) enhancement and empowerment opportunities. This is strongly interlinked with the need to create alternative, renewable land uses that can sustain mining-impacted and surrounding communities, whilst providing sustainable livelihood opportunities.

Review of available literature indicated that a plethora of international and country-specific regulatory and corporate guidelines, and planning tools have been produced, often providing detailed step-wise approaches to the key aspects needing to be included as part of mine rehabilitation and closure planning. Historically and, for the most part, currently, the legislation and guidelines specifically require that land be returned to a condition as close as possible to the pre-mining situation.

The literature also indicated that pre- and post-mining landscapes often differ dramatically from each other, with surface mining involving a twofold change in land use - from a pre-mining landscape to a mining landscape, and then from a mining landscape to a post-mining landscape. Unfortunately, pre-mining land use/s, which are still the predominant post-mining land use goal, are technically, practically and financially challenging to recreate due to the significant alternation of the pre-mining landscape by the mining process.

However, it appears that defining viable post-mining land uses as a core component of setting rehabilitation goals has come to the forefront of countries in which large portions of the mining industries are reaching the end of their life-cycles. This appears to be driven by the scientific understanding that being able to prove achievement of successful rehabilitation is dependent on a well thought-through post-mining land use/s, that have a functional role in a rehabilitated landscape.

The need for a wider regional planning approach as opposed to site-specific plans has also gained momentum. From a sustainability perspective, such regional plans would assist not only in aligning economic contributions in a region, but also to prevent irreparable environmental and social damage to the region. At a local level, site-specific land use planning could be short-sighted and incomplete if not considered as part of the larger landscape. Cross-boundary/neighbour land integration could offer more rehabilitation opportunities purely based on increased geographic footprint areas for ecological habitat/productive land/urban development enhancement. There could also be a pooling of human and financial resources to both fund rehabilitation of disturbed areas as well as manage implemented land uses over time.

Unfortunately, post-mining land use planning epitomises a 'wicked problem' in that it requires consideration and integration of ecological, social, political, cultural and economic drivers which operate over varying temporal and spatial scales. These drivers need to be aligned with the expectations of numerous stakeholders that either impact on the landscape and/or will be affected by its long-term land capability and use. These expectations are often defined by corporate-specific core values that vary between achieving minimum regulatory requirements (compliance) versus those that aim to achieve international best practice (stewardship). Further complications arise with the plethora of scientific disciplines required to define and continually asses the post-mining rehabilitation success trajectory.

South Africa has a plethora of well-written, up-to-date legislation governing mining-related rehabilitation and closure planning. The country has tried to incorporate global trends along with its main goal of transformation and rectification of historical injustices (Brumfitt, 2013). However, as with other developing countries, the nature, depth and strength of much of the available legislation and the ability to monitor and enforce associated obligations vary notably between regions within the country. In addition, the continual change in regulatory personnel makes it difficult for mining companies to establish relationships that could guide adequate rehabilitation planning. There are also varying regulatory role players in rehabilitation, with varying levels of understanding of the complex rehabilitation aspects - this results in varying levels of supporting regulatory input to industry.

As highlighted in this study, in the absence of strong regulatory guidance and legislative enforcement, there is an opportunity for aspects such as rehabilitation planning to benefit from being industry-driven. In support of regulatory policy formation. As industry generates mining-related environmental challenges, they are in the best position to devise suitable solutions. These solutions should be underpinned by supporting academic institutes to ensure implementation and monitoring of scientifically-sound, measurable

post-mining land objectives. This approach could be used to strengthen regulator-industry relationships, enhancing decision-making capabilities by providing viable outcomes for rehabilitation and post-mining land use needs. Hence, when mining companies are operating under limited or non-existent regulatory guidance, monitoring or enforcement of environmental authorization commitments, it is suggested that corporate governance should play this role.

Mine land use-, rehabilitation and closure planning hence requires a true transdisciplinary, collaborative approach. Challenges, solutions and actions should be co-defined, co-created and co-delivered, towards creating a landscape that is ’owned’ by the people accountable for its long-term socio-ecological regeneration and growth.

The *post-mining land use optimisation framework* developed as part of this research underpins the need for examining site-specific decisions within the regional land planning context as well as in relation to the social, economic, and political perspectives within the mine’s localised planning domain. It emphasizes that the spatial and temporal planning and implementation of rehabilitation and land use-related activities remain continually changing throughout the mining life cycle. This implies that amendments, refinements or corrective action should be an integral aspect of this planning, improving the trajectory towards success as new site knowledge and learnings becomes available. Rehabilitation activities should be implemented as soon as site disturbance (construction) starts and maintained throughout the operational and decommissioning periods. More importantly, these activities remain even more pertinent to the monitoring and maintenance period, during which successful implementation of the pre-defined land use/s can be demonstrated.

Rehabilitation-, land use and mine closure plans are hence ‘living’, changing tools, aligned towards a common goal – defining a resilient post-mining landscape that will, ultimately, enable harnessing the altered landscapes’ new characteristics to optimise services to post-mining communities that either provides similar resourcing needs from the land, or alternative resources that contribute to the long-term viability of the area.

This study has indicated that the compilation of a suitable rehabilitation plan in the upfront mine planning stages of an operation, incorporating defined end land use objectives, is imperative in identification of appropriate biophysical and socio-economic post-mining goals that could be agreed with regulators. This would greatly assist towards limiting and even mitigating mining-related environmental impacts in a timely manner. It could also help in reinstating practical, defensible post-mining land uses, developing local skills, creating job opportunities and enhancing long-term post-mining sustainable livelihoods.

Key words:
Post-mining, land use, rehabilitation, planning, regional, framework

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Key terminology used

Term	Definition	Reference
Brownfields	A property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant	United States Environmental Protection Agency (https://www.epa.gov/brownfields/brownfield-overview-and-definition)
Drivers	People, knowledge, and conditions (such as market forces) that initiate and support activities for which the business was designed	http://www.businessdictionary.com/definition/business-drivers.html
Framework	A logical procedure for coordinating decisions that link developmental goals with the actions intended to achieve those goals	Australian Government (2006)
Greenfields	An area of agricultural or forest land, or some other undeveloped site earmarked for commercial development or industrial projects	http://www.businessdictionary.com/definition/greenfield-site.html
Land cover	The classification of land according to the vegetation or material that covers most of its surface	ESRI
Land capability	The potential of land depending on its physical and environmental qualities	Chamber of Mines, 2007
Land use	The purpose which land is or may be used legally in terms of a land use scheme, existing scheme or in terms of any other authorisation, permit or consent issued by a competent authority and includes any conditions related to such land use purposes	Spatial Planning and Land Use Management Act, No. 16 of 2013
Land use management system	System of regulating and managing land use and conferring land use rights through the use of schemes and land development procedures	Spatial Planning and Land Use Management Act, No. 16 of 2013
Land stewardship	Responsibility for sustainable development shared by all those whose actions affect environmental performance, economic activity, and social progress, reflected as both a value and a practice by individuals, organisations, communities, and competent authorities	ISO 20121 (par. 3.20)
Post-mining land use	A land use which occurs after the cessation of mining operations	Australian Department of Resources, Energy and Tourism (2011)

Term	Definition	Reference
Principles	Fundamental norms, rules, or values that represent what is desirable and positive for a person, group, organization, or community, and help it in determining the rightfulness or wrongfulness of its actions. Principles are more basic than policy and objectives, and are meant to govern both.	http://www.businessdictionary.com/definition/principles.html
Productivity	A measure of the amount of agricultural output produced for a given amount of inputs, such as an index of multiple outputs divided by an index of multiple inputs (e.g., the value of all farm outputs divided by the value of all farm inputs)	http://institutmichelserres.ens-lyon.fr/spip.php?article39
Restoration	The artificial acceleration of the processes of natural succession by putting back the original ecosystem's function and form	Post-mining Alliance (http://www.postmining.org/index.php - January 2015)
Rehabilitation	The return of disturbed land to a stable, productive and self-sustaining condition, consistent with the post-mining land use	Australian Department of Mines & Petroleum (2010)
Remediation	To clean-up or mitigate contaminated soil or water	Australian Department of Resources, Energy and Tourism (2011)
Reclamation	Treatment of previously degraded and often contaminated land to achieve a useful purpose	Australian Department of Resources, Energy and Tourism (2011)
Regeneration	Consideration of broad socio-economic and environmental aspects so that the post-disturbed landscape can return economic and ecological benefits to offset negative closure impacts	Post-mining Alliance (http://www.postmining.org/index.php - January 2015)
Settlement	Occupation of land by humans, typically referring to patterns of residential use, from dispersed to concentrated, along a continuum from rural to village to suburb to city. The term may also include infrastructure and commercial land use patterns	Dale *et al*, 2000
Sustainable land management (SLM)	Use of land resources for the production of goods and services to meet changing human needs	Barkemeyer *et al* (2015)

Key acronyms and abbreviations used

Acronym or abbreviation	Definition
AGIS	Agricultural geo-referenced information system
AHP	Analytical hierarchy process
BFAP	Bureau for Food and Agricultural Policy
Coaltech	Coaltech Research Association (South Africa)
CIESIN	Center for International Earth Science Information Network
CoM	Chamber of Mines
CSP	Concentrated solar power
DAFF	Department of Agriculture, Forestry and Fisheries (South Africa)
DCLG	Department for Communities and Local Government (United Kingdom)
DEA	Department of Environmental Affairs (South Africa)
DITR	Department of Industry, Tourism and Resources (Australia)
DOE	Department of Energy (South Africa0
DMR	Department of Mineral Resources (South Africa)
DWS	Department of Water and Sanitation (South Africa)
EEZ	Ecological and economic zoning
EIA/EMP	Environmental impact assessment/environmental management plan
EGS	Ecosystem goods and services
ELLA	Evidence and Lessons from Latin America (South America)
EMP	Environmental Management Plan
EP	Ecosystem properties
EPA	Environmental Protection Authority
ERR	Environmental risk assessment
ES	Ecosystem services
ESA	Ecological Society of America
FAO	Food and Agriculture Organisation of the United Nations
GIS	Geographic information system
GDP	Gross domestic product
ICMM	International Council on Mining and Metals,
IDP	Integrated Development Plan
IFC	International Financial Corporation
IOER	Institute of Ecological and Regional Development (Germany)
IRP	Integrated resource plan
LMA	Land management area
LSA	Land suitability analysis
LUCIS	Land Use Conflict Identification Strategy
LUDS	Land use decision support
LUZ	Land utilization zones
MASA	Multi-attribute decision-making

Acronym or abbreviation	Definition
MEA	Millenium Ecosystem Assessment
MEM	Ministry of Energy and Mines (Peru)
MLSA	Mined Land Suitability Analysis
MPRDA	Mineral and Petroleum Resources Development Act, No. 28 of 2002 (South Africa)
NAOMI	National Orphaned/Abandoned Mines Initiative (Canada)
NDP	National Development Plan
NEMA	National Environmental Management Act, No. 36 of 1996 (South Africa)
NGO	Non-governmental organisation
NWA	National Water Act, No. of 1998 (South Africa)
PDALA	Preservation and Development of Agricultural Land Act (South Africa; yet to be promulgated)
PSR	Pressure-state-response
PV	Photovoltaic
RA	Risk assessment
RAME	Research Association Mining and Environment (Vietnam)
SA	South Africa
SANBI	South African National Biodiversity Institute
SANBI BGIS	South African National Biodiversity Institute biodiversity geographic information system
SDF	Spatial Development Framework
SLP	Social and Labour Plan (South Africa)
SPLUMA	Spatial Planning and Land Use Management Act, No. of 2013 (South Africa)
UCG	Underground coal gasification
UK	United Kingdom
UNEP	United Nations Environmental Programme
USA	United States of America
WfW	Working for water (South Africa)
WHO	World Health Organisation
WRC	Water Research Commission

CHAPTER 1: INTRODUCTION

1.1 Background

Land use, by nature of the term, implies the way land is used by humans for a defined purpose. This purpose may result in one use (or activity), or a suite of uses. In most instances, one landscape can support numerous land uses which are often all inextricably interlinked; thereby creating a multifunctional, multidimensional landscape. Over the centuries, the total land area dedicated to human uses such as settlement, agriculture, forestry, and mining has grown dramatically, and increasing production of goods and services has intensified both use and control of the land. At present, much of earth's habitable surface is dedicated to human use, mostly for production of food and fiber. Some is used for conservation, but even that area is largely mapped, zoned, and controlled (Dale *et al*, 2000).

As global human population rises, so too does the need for more land for human use, regardless of the capability of the land to support these uses. Changing land use demands on the land introduce new conflicts between competing needs for remaining natural resources, suitable uses of the land, specific interests of individual land users and the 'common good'. Land utilised for towns, mining and industry is no longer available for farming; likewise, the development of new farmland competes with forestry, water supplies and conservation initiatives.

South Africa's economy is highly fossil fuel dependent, with the main source (91%) of electricity being coal (Benchmark Foundation, 2014). In addition, apart from the heavy domestic reliance on coal as a source of energy, the country is also a significant participant in global coal markets. Most of South Africa's coal reserves and mines are in the Central Basin, which includes the Witbank, Highveld and Ermelo Coalfields, Mpumalanga Province (Figure 1). South Africa's economically recoverable coal reserves are estimated at between 15 and 55 billion tonnes, and coal production in the Central Basin is likely to peak in the next decade (Benchmark Foundation, 2014).

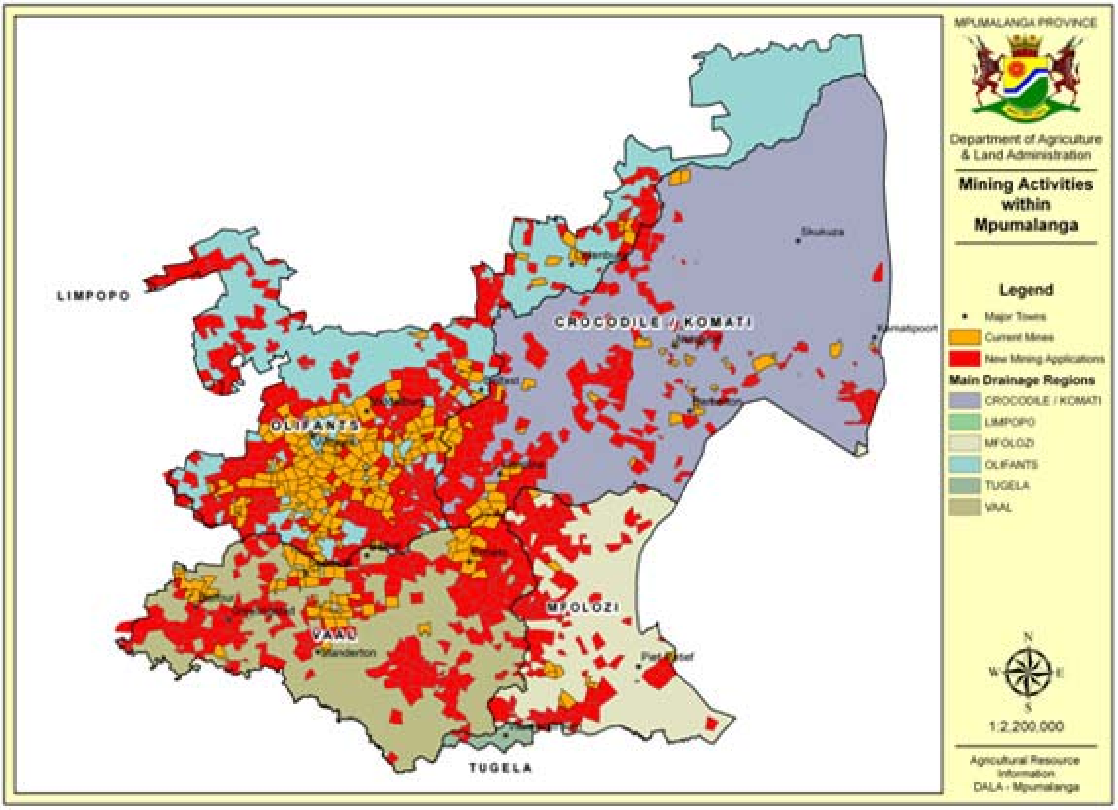

Figure 1: Geographic layout of the operational (orange) coal mines and new mining applications (red) in the Central Basin (eMalahleni, Highveld and Ermelo Coalfields) **(http://www.mpumalanga.gov.za/, accessed August 2015)**

Aligned to the above, the competition for natural resources in South Africa is often most visible where mining and agriculture compete for high value agricultural land (BFAP, 2015). This is vastly evident in the coal Central Basin. The 2015 assessment undertaken by the Bureau for Food and Agricultural Policy (BFAP, 2015) indicated that approximately 46% of South Africa's high potential arable soils are located within Mpumalanga, with roughly 27% of this land being mine-owned land intersected by agriculture (grains and oilseed croplands). This emphasises local debates as to the long-term impact of mining on food production in the region and how suitable mining-related rehabilitation practices could either destroy or enhance post-mining land uses that support ongoing, future (possibly alternative) food production. Hence, no longer is the focus on re-instating pre-mining land use/s; supporting science and practical experience has long negated the possibility of this. Attention is now on improving land capabilities of disturbed land, to a point that a predefined land use can be achieved.

However, food security remains but one land use driver under the spotlight in this mining area. Competing land uses and the often-inappropriate management principles applied to these uses throughout the mining cycle also place constraints on other regional natural resources such as water, air and ecosystem functionality and associated goods and services.

Rural and urban communities within these areas are affected not only by the cumulative impacts on natural resources associated currently with these conflicting land uses, but also by envisaged latent and residual impacts, many of which are still difficult to identify or quantify.

Barkemeyer *et al* (2015) use the term 'wicked problem' to describe situations that are highly challenging, contradictory in nature and dynamic; 'they also suffer a lack of clarity in terms of a route towards an optimal solution'. Post-mining land use planning epitomises a 'wicked problem' in that it requires consideration and integration of ecological, social, political, cultural and economic drivers which operate over varying temporal and spatial scales. These drivers need to be aligned with the expectations of numerous stakeholders that either impact on the landscape and/or will be affected by its long-term land capability and use. The quality of the rehabilitated landscape is often defined by corporate-specific core values that vary between achieving minimum regulatory requirements (compliance) versus those that aim to achieve international best practice (accountability and stewardship). Further complications arise with the plethora of technical disciplines required to define and continually asses the post-mining land's capabilities, such as engineering, spatial planning, landscape architecture, ecology, social science, etc. Overarching local and national legislative regulations, guidelines and policies are meant to focus site-specific planning, but these are often restrictive from an implementation perspective. And, as if this wasn't 'wicked' enough, ownership conflicts around long-term management and accountability of latent and residual post-mining environmental liabilities, within the rehabilitated landscape, further complicates what the land will- and can be used for into the future.

1.2 Problem statement

Historically, land use planning appears to have been focused too narrowly on land resources without enough thought given to how these resources might be used (Dale *et al.*, 2000). Land use decisions cannot be made purely based on the land's physical capabilities as defined by the quality and quantity of available natural (albeit altered) resources. Consideration also should be given to regional planning objectives, the needs of local people and living organisms reliant on the land, local and regional demands for land-related products, and the opportunities for satisfying those demands on the available land, now and in the future.

Based on the above it is evident that the way that land is used has a profound impact on the surrounding quality and availability of natural resources as well as on the quality of life of people and living organisms dependent on the land.

The above is especially evident in areas where large-scale disturbance by industries such as mining can be found. Not surprisingly, mine rehabilitation and closure has become an integral component of the mining life-cycle planning and implementation. Unfortunately, the importance of defining the post-mining next land use/s upon which rehabilitation objectives and measures can be devised is still largely omitted from this planning. At present, a mine's Environmental Management Plan (EMP) provides commitments to achieving broad land use objectives but these are often linked unrealistically to reinstating the post-mining land use/s, assuming that the rehabilitated landscape will have the same/similar land capabilities to the pre-mining landscape. Or even unrealistically that the post-mining community land needs will be the same/similar to the pre-mining needs. However, since landscape rehabilitation becomes inherently more difficult as the level of disturbance increases, this often results in onerous and costly procedures that attempt to reconstruct landscapes according to pre-disturbance physical environments and associated ecological functions (Doley *et al*, 2012).

In addition, there is always a possibility of decommissioned mines reopening – whether it be in response to having been previously mothballed due to uneconomical productive cycles, or for reprocessing of historically discarded 'waste residues'. Local community pressures could drive recreation of alternative landscapes based on their perceived future land needs, and impacts of climate change will affect landform designs as well as selection of suitable vegetation that is resilient to changing temperature and rainfall patterns. These factors, together with the above biophysical impacts imposed by mining implies that reinstating pre-mining land capabilities using remaining 'natural' resources, within an ever-changing physical, social and environmental context, is highly unlikely.

Furthermore, the need for a more holistic regional mine closure planning approach is still in its infancy. This could encourage interlinking of individual mine sites' rehabilitation objectives as well as incorporating the needs of other adjacent land users. Such a holistic approach offers several planning and post-rehabilitated landscape benefits – a consolidated strategy that underpins regional needs and hence would more likely be supported by regulators; pooling of human, natural and financial resources across organisations towards limiting site-specific expenditure (both for managing and monitoring latent impacts and enhancing socio-economic gains); and increased footprint areas available for ecological and agricultural corridor or landscape creation.

In the Chamber of Mines' (CoM) Guideline for the Rehabilitation of Land Disturbed by Surface Coal Mining in South Africa (2007), it is noted that '*if proper land rehabilitation follows in the wake of mining, then the alienation of land need be no more than temporary…, reduction in the utility of land need be no more than slight and environmental effect imperceptible. Mining and agriculture are not necessarily mutually exclusive except over a relatively short period of time*.' However, the guideline is also very clear in defining that the 'term *rehabilitation* means that the land will be returned to a form and productivity in conformity with a <u>land use plan</u> drawn up before mining commences.' Herein lies the current problem with mining-related rehabilitation planning and the associated non-optimisation of post-mining rehabilitated land uses – lack of dedicated upfront post-mining land use planning.

1.3 Research focus

1.3.1 Research hypothesis

The research hypothesis for this study is as follows:

By understanding the land use requirements of the post-mining landscape, the mine's ability to achieve its rehabilitation goals will improve.

1.3.2 Research aim

The research aim is to devise a planning framework to assist mines to systematically define the post-mining rehabilitated environment from a land use perspective, towards optimisation of a functional, post-mining rehabilitated landscape that is socially, ecologically and economically value-generating into the future.

The planning framework focuses on South African (SA) surface coal mining operations, based on the following:

- The project has been funded by the South African Coaltech Research Association (Coaltech), which is aimed at developing technology and applying research findings that will enable the South African coal industry to remain competitive, sustainable and safe into the 21st century; and
- The subtle rehabilitation nuances across differing resources' mining methods, related rehabilitation approaches and possible latent and residual environmental liabilities result in a plethora of possible rehabilitation and land use scenarios which may not be possible to capture in one framework.

However, although the above coal-mining specific framework specifications have been put in place, post-mining land use understanding across resources has similar upfront planning requirements. Hence, it is aimed that the devised framework could be retrofitted across mining resources; the approach to the active land management of the already rehabilitated landscape would be where resource-specific nuances would become more relevant.

1.3.3 Research methodology

The research methodology followed for this study is as follows:

- Undertaking a desktop review of current, available local and international literature, to:
  - Gain an international perspective of the current mining-related land use work being developed and/or implemented; and
  - Identify key planning approaches, drivers and/or principles that could be used to guide post-mining land use planning.
- Devising a preliminary post-mining land use optimisation framework, based on the findings of the literature review, that can help guide conceptualization of a post-mining land use goal against which rehabilitation measures can be devised.

- Gaining an industry perspective of the preliminary framework by undertaking focused one-on-one interviews with key coal mining environmental team members, to:
  - ‘Test’ the suitability and feasibility of the preliminary framework with key industry role players – both its structure and content; and
  - Develop a final framework, refined from learnings gained during the interviews.
- Concluding the findings of the study, providing a summary of key research outcomes – together with the final framework, as well as any possible work that may be required going forward.

The above approach is illustrated in .

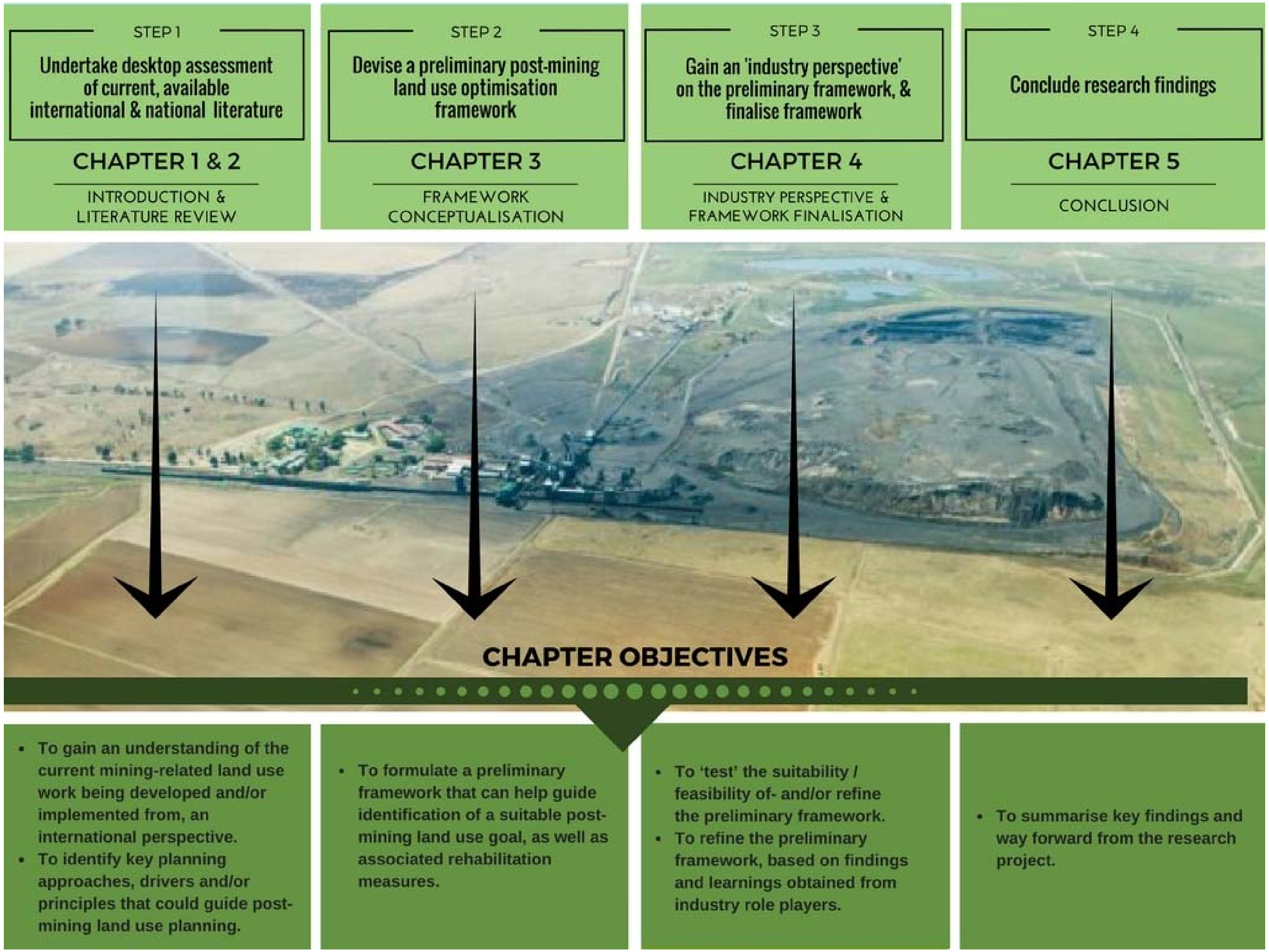

Figure 2: Methodology followed for this research project

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Mining is the fifth largest industry in the world, and hence has a significant role to play in underpinning the prosperity of current and future generations. South Africa, specifically, is the home to 3.5% of the world's coal resources, and is ranked as the 6^{th} largest coal-exporting nation (Chamber of Mines, 2017). However, although the dominance of multi-national corporations in the mining sector means that this group is key in the maintenance of land quality into the future, it has been largely overlooked in terms of its potential to propel land quality towards a more sustainable trajectory (Barkemeyer *et al*, 2015).

To date, much of the research on the impacts on mining has been focused on understanding and reducing local social and environmental impacts and on national concerns of security of supply (Guirco and Cooper, 2012). However, this research has failed to consider the overarching planning sphere in which these impacts and their subsequent management can be accurately defined, from a long-term land use perspective.

To guide the development of a mining-related land use planning framework for the SA mining industry, review of relevant and/or recently published literature, legislation and industry standards was required to identify existing global approaches to this land use planning.

This section provides the findings of the above reviewed key global mining-related land use literature relevant to this research. Although most land use planning-related literature appears to be rural- and/or urban development focused, it is noted that for this study attention has been placed within the mining environment, and not within the urban planning environment. However, as there are underpinning similarities between mining- and urban development-related land use upfront planning concepts, where applicable, reference has also been made to literature related to mining- and urban development-related land use planning.

2.2 Terminology: land use, rehabilitation and mine closure planning

Much of the terminology around mining-related land use-, rehabilitation- and eventual mine closure planning appears to often be confused with each other. Although the eventual goals may be similar, each term implies a specific action or activity that requires individual planning consideration. Omitting one of these activities could result in notable gaps when planning for the post-mining landscape.

Land use planning is the systematic assessment of land and water potential, alternatives for land use and economic and social conditions to select and adopt the best land use options (International Council on Mining and Metals, 2011). Its purpose is to select and put into practice those land uses that will best meet the needs of the people while safeguarding resources for the future. Although its objectives are set by social or political imperatives and must take account of the existing situation, the driving force in land use planning is the need for change, the need for improved management and/or the need for a quite different pattern of land use dictated by changing circumstances (such as those induced by mining). Ultimately, land use planning involves anticipation of the need for change as well as reactions to it.

As part of land use planning, *land capability* refers the potential of land depending on its physical and environmental qualities (Chamber of Mines, 2007). All land uses require a specific land capability or suite of land capabilities for successful implementation. The South African Department of Agriculture, Forestry and Fisheries (DAFF) currently makes provision for eight land capability classes. The land capability classification is an expression of the effect of physical factors for crop suitability and potential that require regular tillage, for grazing, for forestry and for wildlife without damage to the resource. In contrast, the mining industry makes provision for only four land capability classes which are predominantly listed as shown in Table 1 (BFAP, 2015).

Table 1: DAFF land capability classes compared with 4 used by the mining industry (adapted from BFAP, 2015)

<table>
<tr><th>Land capability class</th><th>Soil depth</th><th>Classification by DAFF</th><th>Classification used by mining</th></tr>
<tr><td>I</td><td>>800</td><td>Arable land suitable for very intensive cultivation</td><td rowspan="4">Arable land</td></tr>
<tr><td>II</td><td>>700</td><td>Arable land suitable for intensive cultivation</td></tr>
<tr><td>III</td><td>600 – 800</td><td>Arable land suitable for moderate cultivation</td></tr>
<tr><td>IV</td><td>500 – 700</td><td>Arable land suitable for light cultivation</td></tr>
<tr><td>V</td><td>400 - 600</td><td>Grazing land suitable for moderate grazing but not for forestry</td><td rowspan="3">Grazing</td></tr>
<tr><td>VI</td><td>300 -500</td><td>Grazing suitable for moderate grazing</td></tr>
<tr><td>VII</td><td>100 – 400</td><td>Grazing land suitable for light grazing</td></tr>
<tr><td rowspan="2">VIII</td><td rowspan="2"><100</td><td rowspan="2">Wildlife</td><td>Wilderness</td></tr>
<tr><td>Wetland</td></tr>
</table>

Each of these land capabilities has a limited list of criteria to ensure the necessary soil properties essential to support specific post-mining land capabilities and associated land uses[1]. Soil depth is currently the only determinant of land capability class used by the mining industry which is not sufficient in describing the complexities of land capability (*pers. comm.* Dr Wayne Truter, 2016). Conversely, the DAFF classification considers topography-induced flood and erosion hazards, soil depth, texture, internal drainage, mechanical limitations and acidity, as well as climatic factors such as moisture availability, amount of moisture, length of the temperature seasons, frost, wind and hail hazards (http://www.agis.agric.za/agisweb/landcapability.html). More attention is needed to create a set of sufficient criteria to achieve better success with rehabilitation in future. However, this will contribute to a significantly higher rehabilitation cost initially, since more expertise and inputs are required pre- and often post-rehabilitation (BFAP, 2015),

Rehabilitation is the transformation of land from its original condition, (such as through mining), to a new and beneficial condition (Dale *et al.*, 2000). From a mining perspective, rehabilitation of disturbed land results in the return of the land to a stable condition capable of supporting permanent use as directed by a mine plan. This new, rehabilitated state must contribute to environmental improvement and must be consistent with surrounding aesthetic values, but can be different to the historical state of the land (Limpitlaw and Briel, 2012). In general terms, mine rehabilitation is usually aimed at ensuring that the final land use and morphological character of the site are compatible with either the current state of the surrounding area, or with that of the pre-mining environment (Soltanmohammadi *et al*, 2010). However, as increasingly large areas are being transformed by mining, especially in mining belt areas characterised by extensive mineral deposits, the latter is becoming difficult or even impossible to achieve in such areas.

For the purpose of this study, there are six stages defined within a mine's life cycle – exploration/feasibility, construction, operations, decommissioning, monitoring-and-maintenance, and closure/site relinquishment. Once successful achievement of rehabilitation criteria has been demonstrated and regulators are willing to sign-off on this success, site relinquishment to a new land owner is possible. Hence, although the term *mine closure* is often used to describe the period after decommissioning - once operations have ceased, it is actually the point at which eventual sign-off of the rehabilitated land to a new/alternative owner is achieved. For this study, mine closure is the ultimate goal; the point at which the reinstated land uses on the rehabilitated land are proving to be environmentally, socially and financially sustainable within the post-mining landscape.

[1] It is noted that at the time of compilation of this research report, the DAFF is in the process of refining the above eight land capability classes, and associated selection criteria. However, as these have not yet been promulgated at the time of this study, they have not been considered during compilation of this study.

Figure 3 illustrates the aforementioned terms individually, and their interrelationship within the planning discipline, towards achieving a sustainable post-mining landscape.

Critical to Figure 3 is that the spatial and temporal planning and implementation of rehabilitation and land use-related activities remain continually changing throughout the mining life cycle. This implies that amendments, refinements or corrective action should be an integral aspect of this planning, improving the trajectory towards success as new site knowledge and learnings becomes available. Rehabilitation activities should be implemented as soon as site disturbance (construction) starts and maintained throughout the operational and decommissioning periods. More importantly, these activities remain even more pertinent to the monitoring and maintenance period, during which successful implementation of the pre-defined land use/s can be demonstrated. Rehabilitation-, land use and mine closure plans are hence 'living', changing tools, aligned towards a common goal – eventual site relinquishment of an ecologically and socially functioning landscape asset for future generations.

2.3 Mining land use planning context

The mining industry plays a vital part in national economy of many developing countries, and constitutes a very important source of revenue to governments. This contribution often provides policy makers with hard decisions - they are required to find a balance between national economic growth and protecting the environment (Cao, 2007).

In addition, for most companies, health and safety, and biophysical factors have had the greatest level of influence on post-closure land use decisions in the past. This is to be expected, as leaving the site in a stable and safe condition has long been the primary objective of rehabilitation plans. These are critical sustainability issues as well as being the factors most likely to lead to a legal liability if not well-managed.

This section summarises key legislative, corporate and other planning requirements against which mining-related land use planning is currently taking place.

2.3.1 Internationally-available tools, standards and guidelines

Countries with a mining sector commonly incorporate environment protection requirements such as waste disposal, water quality controls, rehabilitation and occupational health and safety within the relevant mining laws. Others specifically target the public's health and safety, the environment and aesthetics in the legislated rehabilitation requirements (World Health Organisation & United Nations Environmental Programme, 1998).

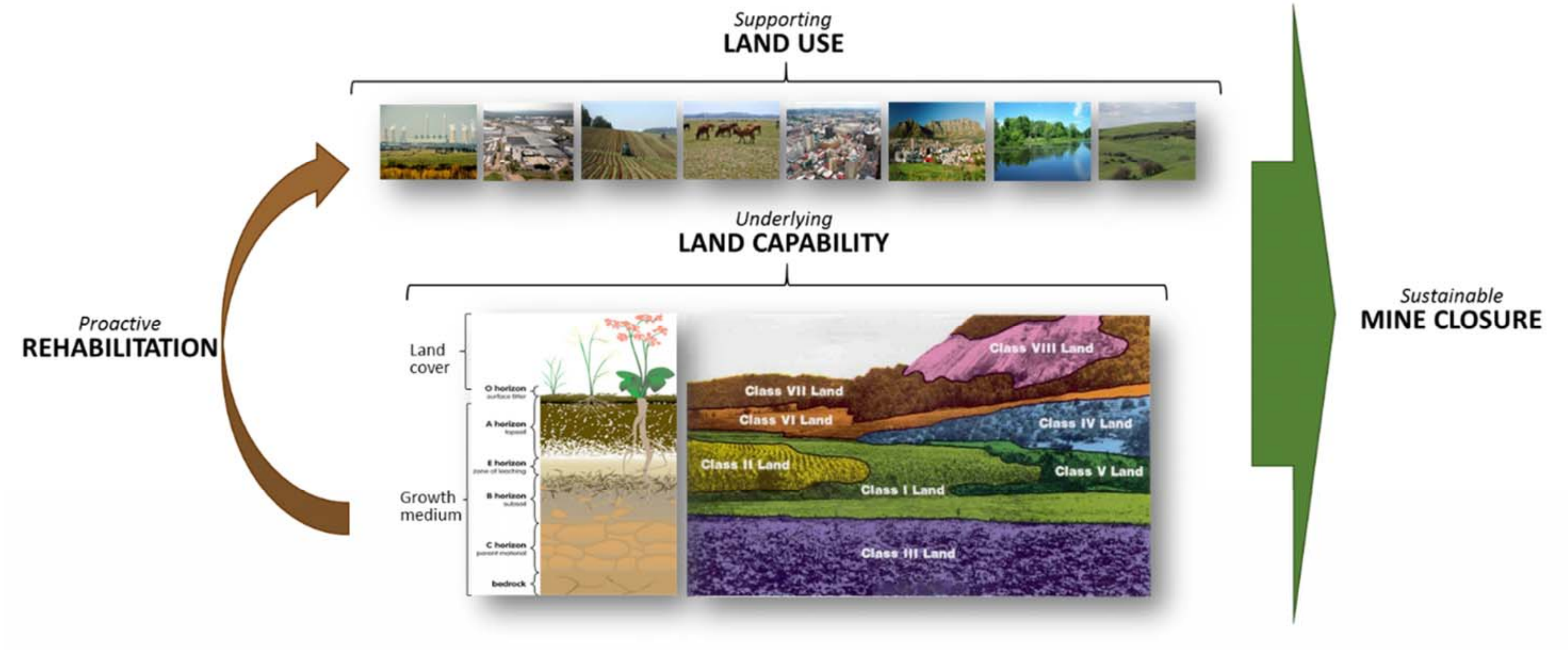

Figure 3: Inter-relationship of land capability, land use, rehabilitation and mine closure, as a function of planning towards a post-mining landscape

Many guidelines, standards and policies have been compiled globally, aiming to guide or strategically focus mining-related rehabilitation and mine closure planning. Most of these guidelines have been compiled by key industry role players such as the mining houses, supporting financial institutes, or governing bodies such as the International Council on Mining and Metals (ICMM). Table 2 summarises the key internationally-available industry guidelines, standards, or other documents specific to mining-related rehabilitation, land use and/or closure planning.

Table 2: Summary of key internationally available industry guidelines, standards, policies, or other documents pertinent to mining-related rehabilitation, land use and/or closure planning

Document	Date	Author		Relevance to land use planning
Anglo American Mine Closure Toolbox, Version 2	2013	Anglo American	Industry (coal)	Within available guidelines, probably the most comprehensive document available for mining-related rehabilitation, land use and closure planning. Aims to expand the focus of mine closure planning from financial provisioning for rehabilitation and physical closure to planning for sustainability beyond mine closure, and leaving behind a positive mining legacy. Land use is a specific biophysical component requiring consideration as part of the Toolbox.
Anglo American Socio-Economic Assessment Toolbox (SEAT), Version 3	2012	Anglo American	Industry (coal)	Not specifically closure-related, but includes how to identify key social and economic impacts and issues needing management, towards a sustainable mining environment outcome.
Equator Principles III	2013	International Financial Corporation (IFC) / World Bank	International governing body	Adopted by companies requiring IFC support. Principles provide key aspects requiring attention during project planning to ensure that projects financed by the IFC are socially responsible and reflect sound environmental practices. Land use planning is encouraged through cumulative landscape impact identification, as well as the need for an understanding of how affected communities would be managed over time.
IFC Performance Standards on Environmental and Social Sustainability	2012	IFC	International governing body	As with the Equator Principles, the IFC expects its member companies to comply with the eight Performance Standards as provided in this document. Compliance with these standards

Document	Date	Author		Relevance to land use planning
				will help manage environmental and social project risks and impacts, towards enhancement of the project development opportunities. Performance Standard 5: Land Acquisition and Involuntary Resettlement emphasizes the need for any new or alternative land uses needing to still ensure livelihoods for people affected by the operations. Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources focuses on the importance of ensuring long-term ecosystem goods and services within the operational landscapes.
Planning for Integrated Mine Closure: Toolkit	2008	ICMM	International governing body	Provides guidance on how closure planning should be undertaken within a holistic approach. Intended to be used to promote a more disciplined, holistic approach to integrated closure planning, and to increase the uniformity of good practice across the sector. It covers the need to identify alternative post-mining land use opportunities, and to base rehabilitated landform designs on these uses.
Mine Rehabilitation for Environment and Health Protection	1998	United Nations Environment Programme (UNEP) and World Health Organisation (WHO)	International governing body	Applied, hands-on guide to address rehabilitation of mining-related disturbed land. Detailed measures for each aspect of rehabilitation, with focus on environmental planning, 'landscaping', physical and chemical soil amelioration, monitoring, etc. No socio-economic focus.

2.3.2 International land use planning perspective

In addition to the above, individual countries place varying degrees of focus on mining-related rehabilitation and land use planning. This section highlights those global countries for which notable mining-related rehabilitation and land use planning literature.

Australia

All the states (New South Wales, Western Australia, Queensland, South Australia, Victoria) and the Northern Territory in Australia have jurisdiction-specific mine closure legislation. In general, the mineral acts provide statutory requirements enforcing the management and rehabilitation of the affected environment of mining. Detailed guidelines of mine closure (for example, Government of South Australia 2009, Government of South Australia 2012, Environmental Protection Agency 2011, Queensland Mineral Council 2001) area available in each of the states except the Northern Territory and New South Wales (Kabir, *et al*, 2015). Table 3 highlights the key Australian documents available to guide mining-related rehabilitation, land use and closure planning.

Table 3: Summary of key Australian documents available to guide mining-related land rehabilitation, land use and closure planning

Document	Date	Author		Relevance to land use planning
Leading Practice Sustainable development program for the mining industry: mine closure.	2016	Australian Government of Industry, Innovation and Science	Regulator	Emphasises that the concept of completion and relinquishment incorporate delivery of a defined post-mining land use. Provides a dedicated section of post-closure management which focuses on longer-term considerations for companies to manage post-decommissioning conditions. It also identifies the need for closure planning to consider cumulative impacts – a regional planning approach.
Guideline for Preparing Mine Closure Plans	2010	Department of Mines and Petroleum (DMP) and Environmental Protection Authority (EPA)	Regulator and government chief environmental advisor (EPA)	Guideline that supports compilation of MCPs in terms of the Australian Mining Act 1978, as well as Environmental Protection Act 1986. Detailed land use components, as follows: • Proposed post-mining land uses need to be identified and agreed upon through consultation before approval of MCPs. • Identified land uses must be relevant to the environment, acceptable to stakeholders and sustainable within the local and regional environment.

Document	Date	Author		Relevance to land use planning
				• Proponents are encouraged to consider applying resources to achieve improved land management and ecological outcomes on a wider landscape scale, using the following hierarchy: ▪ 1. Reinstate "natural" ecosystems as similar as possible to the original ecosystem. ▪ 2. Develop an alternative land use with higher beneficial uses than the pre-mining land use. ▪ 3. Reinstate the pre-mining land use. ▪ 4. Develop an alternative land use with other beneficial uses than the pre-mining land use
Mine Rehabilitation: Leading Practice Sustainable Development Program for the Mining Industry	2006	Department of Industry, Tourism and Resources (DITR)	Regulator	Outlines the principles of mine rehabilitation, with emphasis on landform design and revegetation. Refers to the need to devise post-mining land use options upfront, considering the needs and capabilities of the communities. It also highlights the different long-term needs for land management depending on the complexity and/or management requirements of the post-mining land use.
Mine Closure and Completion: Leading Practice Sustainable Development Program for the Mining Industry	2006	Department of Industry, Tourism and Resources (DITR)	Regulator	
Guidelines for Mining in Arid Environments	1996	Department of Minerals and Energy, Western Australia	Regulator	Focuses on arid environments. Includes setting land use objectives, devising rehabilitation measures, as well as setting monitoring measures and completion criteria.

Research focus in Australia has, to date, concentrated on how to undertake rehabilitation of essential landform elements to provide functional post-disturbance ecosystems. As Australia has a relatively low population density with many of the larger mining operations situated far from dense urban areas, current rehabilitation practices aim to achieve a range of beneficial ecosystem services via the reintroduction and conservation of native biodiversity (Tibbet *et al*, 2012). Concurrently, grazing is a commonly identified post-mining land use, as many of the mining operations are located on land previously used for cattle grazing. As highlighted by Maczkowiack *et al* (2012), in Australia, grazing is also seen as a use suited to rehabilitated mine land due to the lower land productivity required compared to cropping.

However, although Australia appears to currently have some of the most comprehensive mining-related rehabilitation and closure legislation and guidelines in the world, as well as a developing base of risk-based post-mining land use research (Maczkowiack *et al*, 2012; Tibbet *et al*, 2012; Doley *et al*, 2012; Cummings, 2014, Kabir *et al*, 2015) comprehensive measures of the long-term success and sustainability of these rehabilitated landscapes, and ultimate mine closure certification and post-mining land usage, remain elusive. Furthermore, Cummings (2014) questions whether the country's momentum in landscape and mining-related rehabilitation research, development and communication is being maintained. Instead, it appears that the most recent significant innovations in land rehabilitation have developed from partnerships driven by non-government organisations with academic institutions and agriculture-focused landowners.

Canada

Under the Canadian federal system, responsibility for mining falls within the exclusive domain of the provinces. The country has instituted a series of legislative initiatives designed to create procedural and enforcement mechanisms supportive of mine closure planning, implementation and assessment across all provinces (Kabir *et al*, 2015). In addition, most provinces have a detailed guideline for mine closure, providing practical on-site guidance.

The country also has a long history of mining which has resulted in abandoned mines in all jurisdictions (Boyer, 2015). Accordingly, in 2002, the National Orphaned/Abandoned Mines Initiative (NAOMI) (Cowan *et al.*, 2013) was established to try address the issue. Table 4 highlights the key Canadian documents available to guide mining-related rehabilitation, land use and closure planning.

Table 4: Summary of key Canadian documents available to guide mining-related land rehabilitation, land use and closure planning

Document	Date	Author		Relevance to land use planning
Guidelines for the Development of Closure and Reclamation Plans for Advanced Mineral Exploration and Mine Sites in the Northwest Territories	2013	Aboriginal Affairs and Northern Development Canada & Land and Water Boards of the Mackenzie Valley	National governing bodies	Describes a post-mining land use is being a practical, self-sustaining ecosystem compatible with a healthy environment and associated human activities.
Policy Framework in Canada for Mine Closure and	2010	National Abandoned/Orphaned	National governing body	Aimed at providing guidance to operating mines towards limiting the

Document	Date	Author		Relevance to land use planning
Management of Long-term Liabilities: A Guidance Document		Mines Initiative (NAOMI)		potential for future land abandonment, and thereby reducing the risk to the State. Highlights to the importance of setting a post-mining land use objective that is aligned to the mining strategy in the jurisdiction (i.e. regional land use plans).
Environmental Code for Practice for Metal Mines	2009	Environment Canada	Regulator	Lifecycle processing focus, with a dedicated mine closure section. Project/site design aimed towards achieving a defined 'intended post-closure land use'. Reference also made to utilization of available waste rock, surface infrastructure, etc. for post-closure land use.
Northern Land Use Guidelines - various	2003 - 2010	Indian and Northern Affairs Development Canada	National governing body	Set of 12 guidelines, designed to guide land use activities on Crown land in the Northwest Territories, Nunavut and Yukon. Including one for pits and quarries (volume 07). This volume includes elements of site contaminated land clean-up and landscape reconstruction, for the reclaimed area. The guidelines have been compiled acknowledging that sound environmental planning can save time and money in the long run.

An impact management plan is also required to be prepared within the mine closure plan, with management focus on environmental impact management, land rehabilitation, revegetation, and social and economic rehabilitation of affected community and employees. Progressive rehabilitation is one of the key aspect of mine closure planning in Canada (Cowan and Robertson, 2000).

Ultimately, Canada provides a high level of detailed mine closure-related legislation and specific guidelines which are regularly updated. However, as highlighted by Kabir *et al*, (2015), focus still needs to be placed on identifying suitable or feasible alternatives for post-mining land use, better defining post-closure social and community needs, and long-term human and financial responsibilities around performance assessment (rehabilitation monitoring) and implementation of corrective action.

United States of America

As with Canada, centuries of intensive, widespread mining in the US have resulted in a legacy of externalized environmental costs and damage to remaining ecosystem goods and services (Danielson & Nixon, 2010). Accordingly, mining activities in the United States of America (USA) are complex, regulated by various entities, and with states playing a key oversight role. Each mine faces a unique set of regulatory requirements, depending on the state statute or regulation; whether it is on state, federal, tribal or private land; local regulations; the type of mining and metal recovery operation; as well as the specific environmental considerations, relevant to the site.

The national Surface Mining Act contains a long list of performance standards, which include restoration of land to a condition capable of supporting pre-mining uses, or acceptable higher or better uses (Danielson & Nixon, 2010). The general principle underlying the country's laws is that the choice of post-mining land use resides with the private landowner, and is not subject to dictation by government, except to the extent that any land is subject to local zoning, planning, or other land use regulations. Specifically, the closure authority concerns itself not with the end, but with the means: how the plan provides sound technical means to achieve the final land use.

The concept of devising rehabilitation measures that mimic functions in nature (i.e. biomimicry) appear to be a driver of mining and heavy industry-related rehabilitation in the US (Polster, 2011). However, much of this pertains to restoration of ecological functionality, and not necessarily productive land uses. In remote mining areas, cattle or other farming remains a predominant land use of areas adjacent to mining operations. However, literature pertaining to how rehabilitation of these mining sites is being undertaken together with adjacent farming communities was hard to find.

Yet, as the US has a long history of mining, community engagement and integration within mining project planning now appears to be a given. As identified by Comp (2013), despite a seemingly overwhelming legacy of past neglect and public indifference to environmental and social impacts, there are currently small groups of determined citizens working to bring real change to, specifically, the American Appalachian Coal Country. Partnerships are building between US government offices, throughout every state system that administers federal funds, and deep into the private sector (Comp, 2013).

From a wider land use planning perspective, literature indicates that much of the academic and research-based land use planning work in the US is currently developing around the needs of the urban planning environment. Regional land use planning is being undertaken from a watershed or catchment perspective, driven by the need for long-term water supply to urban areas (Norman *et al*, 2012; Lilieholm *et al*, 2012); or from an ecosystem goods and services perspective (Woodruff & Bendor, 2016; Dale *et al*, 2000). Ironically, the Appalachian Coal Country partnerships mentioned above are also founded based on watershed delineations (Comp, 2013).

The US, with its historical environmental and social mining legacies and vast mining footprints should be at the forefront of international mining-related rehabilitation and land use planning. However, from available literature, it appears that Australia and Canada both adopt a strategically more proactive approach than the US to managing the longer-term land needs of their mining areas.

<u>Germany</u>

Germany appears to be at the forefront of land rehabilitation and land use planning, but from an overall urban planning perspective. Mining areas, where relevant, are incorporated into this planning.

The Leibniz Institute of Ecological and Regional Development (IOER) in Dresden is, by the nature of its name, one of the few places in the world with a defined focus on regional landscape planning. In terms of the Federal Spatial Planning Act, mining land use plans are jointly developed as part of municipal and regional spatial plans, ensuring an integrated regional land use framework – the aim is the optimal spatial planning and development of the regions, incorporating the disciplines of ecology, economy, settlements and infrastructure (Isolde, 2011). In addition, land use planning in Germany is being undertaken as a multidisciplinary approach aiming to identify future land use solutions that provide places to live, produce food, supply recreational areas, or help mitigate climate change or temperature rise (which is a top priority of Saxon state regional planning efforts) (Larondelle & Haase, 2012).

Germany also remains as one of the few countries that have a dedicated document for 'regional' land use planning which considers most aspects of natural resource-, socio-economic-, climate change-related drivers (German Federal Ministry for Economic Cooperation and Development, 2011) – *Land Use Planning Concept, Tools and Applications*. This document, although having an underlying urban development theme, also highlights how mine closure in the country appears to be viewed as an opportunity to change both industrial and urban structures in a future-oriented way. Instead of industrial waste land, planning is being put in place to ensure that former mining areas are regenerated towards contributing to the future economic and social well-being of the areas. Accordingly, in the book '101 Things to do with a Hole in the Ground' (Pearman, 2010), the only consolidated published book covering examples of global mine closure, many of the examples come from German case-studies.

It is noted, though, that Germany is a small country with sound, enforced regulatory structures and a wealthy government. Hence, more time, human resources and financial capital are available to devise and implement best practice rehabilitation and land use projects.

United Kingdom

There are over 2000 active mines and quarries in the UK producing a wide range of minerals including construction aggregates, building stone, coal and industrial minerals (British Geological Survey, 2016). There is also a significant footprint of historical decommissioned (and rehabilitated) mining sites.

Most land use planning decisions in Britain are made at a local level by local planning authorities. The Department for Communities and Local Government (DCLG) has responsibility for the operation of the system in England, and in Wales and Scotland control resides with the Welsh and Scottish Governments, respectively. Each of these is responsible for developing national planning policy guidance, including that for mineral development, within which local authorities are required to operate. This aims to secure the most efficient and effective use of land in the public interest and to reconcile the competing needs of development and environmental protection (http://www.bgs.ac.uk/ mineralsUK/planning/ legislation/home.html).

Planning permission goes with the land in the UK, not with the operator. Hence, it remains relatively easy for a mining company to claim bankruptcy or prematurely close, and leave the rehabilitation conditions for the subsequent owner. Coppin (2013) highlights the example of the Wheal Jane mining site where the mining company closed without fulfilling its rehabilitation conditions. However, the regulatory conditions still apply, but the new owner is now responsible for their implementation and funding. In addition, the UK does not require a mining house to provide reclamation bonds or sureties, relying instead on the planning system and the fact that most quarries are operated by 'major miners' with longer term horizons when considering reputation and future permissions (Coppin, 2013).

Demographic pressures in the UK mean that public perception and levels of acceptability of mining and quarrying are very low and getting lower, a factor which is a growing influence on the spatial planning system, as well as on the relationship between mining, other forms of land use and designation (Bloodworth *et al,* 2009). Communities are also usually well-informed and expect to be involved in the land use planning within their areas.

Accordingly, despite a poor record in the past, the former coalfields of the north of England, and the metal mining districts of Cornwall now makes an overall positive contribution to biodiversity and geodiversity which is disproportionate to its land take (Bloodworth *et al*, 2009). For example, the Eden Project in Cornwall is internationally recognized as one of the most successful china clay pit quarry reclamation projects in the world (www.edenproject.com). So successful, this concept is currently being replicated in Qingdoa - China, where planning is underway to create a local 'Eden Project' on a reclaimed but environmentally degraded historical salt pan and prawn breeding site.

Progressive improvements in eco-efficiency are also high on the UK post-mining agenda, focusing on doing more with less through sustainable building, recycling, re-use and product substitution (Dale *et al*, 2000).

China

A surprising volume of mining land use-related literature is available in China.

China has made a comparatively late start in mine land rehabilitation and currently has low rehabilitation rates, with the country facing similar legislative and regulatory challenges as other developing countries (Cao, 2007).

According to the Chinese Ministry of Land and Resources, in 2005 there was over 40,000 km^2 of land disturbed by mining operations, with a calculated annual increase of 200 km^2 (Sheng & Li-zhong, 2009). Although no current figures could be obtained at the time of compilation of this research, using the above figures, it is assumed that as at 2015, China has roughly 42,000 km^2 affected by mining – equivalent to approximately half the province of Mpumalanga, in South Africa.

Literature indicates that local environmental legislation in China is fragmented, with little guidance on rehabilitation or re-use of mining land, especially for those that are historically derelict or abandoned. The required standards for ecological restoration are low (Wang, 2012). Only within the last decade has there been a more vigorous call to put management of environmental impacts posed by mining ahead of the mines' contribution to national economic growth (Cao, 2007). This call has emphasised that while there will be a continued effort to speed up development of mine districts, the land should be reclaimed not only to raise the utilisation rate of land resources and keep the dynamic balance of the total farmland area, but also to restore the ecological balance and promote the sustainable development of ecology, economy and society (Wu *et al*, 2011).

Operations such as those in the Lu'an mining area have resulted in accelerated socio-economic development as people have moved from rural areas looking for work at the mines. This has contributed to conversion of agricultural-based land into urban development, as well as a focus on management of air and water pollution from mining operations (Lui & Ma, 2011).

Although China has some institutes focusing on mining rehabilitation, there efforts appear disjointed and lack a collaborative effort (Wang, 2012). In terms of land use and protection, the provincial, municipal and county administrations all have the power to define their 'organizations and responsibilities' in line with relative provisions of the State Council (Art. 5, LAL). Through a hierarchical process, an Overall Land Use Plan is required from sub-national levels and to be approved for their territories according to the directives set forth in the corresponding higher-level plans (Art. 17 and 18, LAL). However, as is the case in the enforcement of other environmental policy and regulations in other developing countries, the lack of trained staff, funding and effective judicial decision-making process has also contributed to ineffective enforcement of reclamation regulations (Cao, 2007).

In general, much of the focus of mined land use-related research in China appears to be focusing on the driving forces of land use change, and not necessarily how to plan for these changes or to provide for alternative land uses. However, the importance of now focusing on appropriate rehabilitation approaches for operational mines as well as regenerating opportunities for abandoned mined land has been identified as a key land planning driver for the Chinese Regulators to cater for the ever-increasing pressure of the growing population. As stated by Cao (2007), "…given China's increasing population, scant farming land, countless closed pits and deeply scarred landscapes, it is self-evident that China cannot afford to wait to be rich enough to pay for a better environment."

India

Mining areas in India occupy roughly 0.17% of the total land of the country. However, with rapid industrialization and associated infrastructure development, it is foreseen that land under these uses will significantly increase.

The Indian Constitution requires that spatial planning is incorporated in District and Metropolitan Area Development Plans. At a National level, activities are focused to evolving policies, guidelines and model laws for adoption by the States. Accordingly, to date, there has been a lack of comprehensive and integrated land use planning that could enable rational and optimal land utilization (Indian Department of Land Resources, 2013).

However, Development of the National Land Utilisation Policy in 2013 by the Indian Department of Land Resources has greatly improved the level of detail and focus on the countries land use planning. Specifically, the Policy provides guidance on how to delineate six land utilization zones (LUZs) – namely predominantly rural and agricultural areas; areas under transformation; predominantly urban areas; predominantly industrial areas; predominantly ecological areas, landscape conservation and tourism areas, and heritage areas, and major hazard vulnerable areas. These LUZs are then further defined in terms of four land use management areas (LMAs) – namely protected areas, regulatory areas, reserved areas, and guided development areas. Each State Government has been allocated a period of two years (from publication of the Policy) in which to identify and geographically reference their LUZs, as well as to develop a regional development plan for each LUZ.

Importantly, even though it is yet to be seen if implementation of this Policy will take place as required, the systematic, structured and detailed approach highlights India's understanding of the need for such planning for developing countries. It also indicates a strong drive for India to adopt a regional land planning approach, integrating cross-State land needs and opportunities; the importance of which will be described later in this report.

Latin America

Within Latin America - Argentina, Bolivia, Brazil, Chile and Peru, have been highly successful in attracting investment for minerals development in recent years. However, when their legal frameworks for mine closure planning are compared with international good practice standards, Bastida and Sanford (2006) have identified that mine closure regimes in Latin America are still in their formative stages.

In Brazil, the concept of mine closure is not yet fully consolidated. However, as a result of the efforts of state governments, companies, institutes, and mining companies, standards and guidelines on the subject have been developed (Namba *et al,* 2014). Decree No. 97,632 (Brazil, 1989-a) requires the formulation of degraded areas recovery plans during the environmental licensing of mining activities. In Article 3, the decree states that recovery should "aim to provide a use to the degraded area, according to a pre-established land use plan, in order to obtain a stable environment." Additionally, Article 19 of Law No. 7,805 (Brazil, 1989-b) provides that "the holder of exploration license is liable for damages caused to the environment." In this context, NBR 13.030 (ABNT, 1999) has set guidelines for the preparation and submission of projects for rehabilitation of areas degraded by mining activities to enable the maintenance or improvement of environmental quality, regardless of the phase of the project. In Minas Gerais, the main Brazilian mining state, the State Environmental Policy Council's Normative Resolution No 127 stands out as one of the normative instruments of great relevance for establishing guidelines and procedures for environmental assessment of mine closures. Article 3 of this document instructs that the closure of a mine should be planned from the project conception, to ensure that all verified environmental impacts will be mitigated after closing. This article also recommends that, after the closing process, the area should be maintained in a safe and stable condition, with the application of the best control techniques and monitoring, giving the area a future use that is integrated and compatible with its influence area. Article 5 forces the entrepreneur to file a mine closure plan two years ahead of the end of activities (Namba *et al*, 2014). However, even with the above, the Brazilian system does not specify the contents of the rehabilitation plan and contains no mechanism for guaranteeing the financing of rehabilitation (Scalon, 2014).

During November 2012, Chile promulgated Law No. 20.551 That regulates the closure of mining operations and its facilities, through the Supreme Decree No. 41 (Sanzana *et al*, 2015). Under this new law, mining companies are obligated to submit a mine closure plan that guarantees the physical and chemical stability of its facilities after decommissioning. Companies are also required to submit a financial guarantee equal to the value of the implementation costs of the stipulated closure measures, as well as to establish a post-closure fund that could be used to address possible post-closure liabilities. Sanzana *et al* (2015) note that implementation of this new law has been successful due to implementation via a collaborative public-private strategy. This has resulted in over 90% of the country's industry having submitted closure plans within the required timeframes, as well as over US$ 12 million already set-aside within closure funds.

During 2004, the Peruvian Ministry of Energy and Mines (MEM), developed legislation and guidelines for planning and financing mine closure. This legislation was the first-time local industry was required to make available 'adequate financial resources to provide for reasonable closure' (Furst & Pacey, 2004). This legislation also defines the content of closure plans and specifies times lines for compliance.

From an urban land planning perspective, the Latin American countries have had some key successes in implementing land use planning, albeit to varying degrees. Evidence and Lessons from Latin America (ELLA) (2010) highlight the following country-specific perspectives:

- Colombia: In 1991, Colombia established land use planning in its political constitution. By 2007, ~96.9% of municipalities had invested in land risk management, and by 2009 the government announced the implementation of a Land Planning Commission to carry out monitoring.
- Brazil: Ecological and Economic Zoning (EEZ), a tool for examining potential land uses and limitations for different territories (see Section 2.4.1), has been completed in every region of Brazil. The country has implemented the land use planning process starting at the local level, and then moving on to the national level.
- Peru: Almost all regions in Peru have demonstrated the political will to start land use planning processes, but by 2010 only just over a third of regional governments had actually carried out EEZ. Some districts have gone further and developed land use planning instruments. However, the process has been highly disorganised and not all the stages have been completed. So, while Peru has made progress in many of the phases of land planning, many of these developments have only been partially completed. Recently the Peruvian government decided to recentralize the land use planning process to establish dialogue with the private sector, which it saw as being in opposition to the process because it considers EEZ to be too restrictive for new private investments.
- Chile: Chile has undertaken a decentralized model for land use planning, beginning in 2011 when Regional Land Use Plans were implemented with close support from the central government. The Government then completed a national land use assessment, and by the first half of 2011, 14 of its 15 regions had started to elaborate their own Regional Land Use Plans. Even though Chile is technically 'behind' Peru in terms of completing land planning processes, its decentralized approach is now achieving better quality results.
- Mexico: In the case of Mexico, regions have been implementing land use planning since 1995, though many regions are still at the design stage, while some are more advanced. At the national and sub-national level, Mexico has almost completed the formulation stage of land use planning, with 27 of 31 states having completed their State Land Use Plans. However, there has been no advance at the local level since Mexico´s legislation does not require sub-national governments to implement their plans.

Overall, in Latin America, as in other regions, many countries lack public institutions that have strong technical skills and are financially efficient, both of which are required for effective land use planning (ELLA, 2010). ELLA (2010) further highlights that some of these governments have produced useful information for land planning, but that this has not necessarily led to implementation. Where governments are working in a more collaborative way, synergies are generated during the information collection process.

It also appears that larger global corporations operating in these regions are implementing their global good practice corporate policies which are applicable across all the jurisdictions in which they work. In general, these policies are generally well beyond country-specific legislative requirements, but are used to limit long-term company risks and financial liabilities. Hence, there is a need for a better coordination between international and national practice standards, regulatory and voluntary instruments, and more room and mechanisms to encourage the implementation of these good practice standards of mine closure to achieve the best possible results and synergies between the dynamics of global investment and the needs of local contexts (Bastida & Sanford, 2006).

In addition, these countries experience a developing world contradiction of mining revenues being very high, but mining areas remaining very poor (Jeronimo *et al*, 2015). Although current national Latin American mine closure legislation shows a steady evolution of the legal aspects related to the requirement of measures for rehabilitation of degraded areas, there still is a lack of drivers for integrated mine closure, stakeholder engagement, or consideration of the social impacts of closure.

2.3.3 South African perspective

National requirements

Within South Africa, the process of mining is governed by the Mineral and Petroleum Resources Development Act, No. 28 of 2002 (MPRDA), enforced by the Department of Mineral Resources (DMR). Environmental-related aspects are co-governed by the Department of Environmental Affairs (DEA) in terms of the National Environmental Management Act, No. 36 of 1996 (NEMA), and by the Department of Water and Sanitation (DWS) in terms of the National Water Act, No. of 1998 (NWA). Until 2015, the MPRDA was also the underpinning legislation governing the process for mine rehabilitation and closure planning.

During November 2015, the Regulations Pertaining to the Financial Provision for Prospecting, Exploration, Mining or Production Operations (GNR1147) in terms of NEMA, was promulgated. In terms of GNR1147, every mining operation is required to submit to Regulators an Annual Rehabilitation Plan, Environmental Risk Report, and Final Rehabilitation, Decommissioning and Mine Closure Plan. These plans would be submitted in conjunction with the required annual Closure Costing Report detailing determination of allocated financial provision for identified rehabilitation measures. However, since it's promulgation, industry and the country's Chamber of Mines (CoM) have raised numerous concerns with the government, resulting in various amendments to this regulation. At the time of compilation of this report, the Regulation was yet again being re-drafted based on public-private sector engagement. However, companies looking to comply with the Regulations in the interim appear to be using the original November 2015 version, until the Regulations are finalized.

A key implication of this Regulation is that although the DMR retain responsibility for issuing of a closure certificate, the DEA are now the governing authority for mining rehabilitation and closure planning.

South African environmental legislation is trying to move towards a 'One Environment System', which aims at consolidating the responsibilities of the country's regulating bodies (specifically that of the DEA and DMR). However, a notable gap is the lack of integration with- and governance of post-mining land use by the Department of Agriculture, Forestry and Fisheries (DAFF), who are the ultimate regulatory custodians of the country's land. Although DAFF officials are consulted during review of a mine's environmental impact assessment/environmental management plan (EIA/EMP) prior to issuance of a mining right, it appears that this Department has limited say in selection and/or improvement of suitable post-mining land use/s. However, at the time of compiling this report, the DAFF is in the process of promulgating the Preservation and Development of Agricultural Land Act (PDALA). The purpose of this Act appears to focus on the custodianship of "agricultural land" and, inter alia, to regulate the subdivision and rezoning of what is termed high potential cropping land; medium potential agricultural land; and to provide for proclaiming so-called protected agricultural areas. Furthermore, in terms of Section 3 (of the draft Bill), the custodianship of designated "agricultural land" will be assigned exclusively to the DAFF. In Section 3(2), DAFF confirms that, acting through the National Minister or MEC's at provincial level, DAFF will "approve, reject, control, administer, and manage" any rezoning or subdivision of agricultural land. This could greatly impact on authorization of future mining rights located in remaining high potential cropping land; under which much of the country's remaining coal reserves are located.

When considering available literature on South African-specific mining land use-, rehabilitation and/or closure, much of the focused published work has taken place prior to 2007, over ten years ago. The following are used as a few sampled relevant examples:

- Oelofse, S.H.H., Hobbs, P.J., Rascher, J. & Cobbing, J.E. 2007. The pollution and destruction threat of gold mining waste on the Witwatersrand - A West Rand case study. Accessed from: http://www.infomine.com/library/publications/docs/oelofse2007b.pdfInfoMine, 3 March 2016.
- Sutton, M.W., Weiersbye, I.M., Galpin, J.S. & Heller Bar-Kal, D. 2006. A GIS-based history of gold mine residue deposits and risk assessment of post-mining land uses on the Witwatersrand Basin, South Africa. Mine Closure 2006 – Andy Fourie and Mark Tibbett (eds) © 2006 Australian Centre for Geomechanics, Perth, ISBN 0-9756756-6-4.

- Akcil, A. & Koldase, S. 2006. Acid mine drainage: causes, treatment and case-studies. Journal of Cleaner Production. Volume 14, Issues 12–13, 2006, pages 1139–114.
- Fourie, A. & Brent, A.C. 2006. A project-based mine closure model (MCM) for sustainable asset life cycle management. Journal of Cleaner Production. Volume 14, Issues 12–13, 2006, pages 1085–1095
- Limpitlaw, D., Aken, M., Lodewijks, H. & Viljoen, J. 2005. Post-mining rehabilitation, land use and pollution at collieries in South Africa. The South African Institute of Mining and Metallurgy. Presented at the Colloquium: Sustainable Development in the Life of Coal Mining, Boksburg, 13 July, 2005.
- Nel, E.L. & Rogerson, T. 2005. The experience of southern Africa – local economic development in the developing world. Transaction Publishers, New Brunswick (USA) and London (UK).
- Hamann, R. 2004. Corporate social responsibility, partnerships, and institutional change: The case of mining companies in South Africa. A United National Sustainable Development Journal. Volume 28, Issue 4, November 2004, pages 278–290
- Binns, T. & Nel, E. 2003. The village in a game park: local response to the demise of coal mining in KwaZulu-Natal, South Africa. Economic Geography. Volume 79, Issue 1 January 2003, pages 41–66.
- Swart, E. 2003. The South African legislative framework for mine closure. Journal of the Southern African Institute of Mining and Metallurgy, Volume 103, Issue 8, Oct 2003, p. 489 – 492.
- Nel, E.L., Hill, T.R., Aitchison, K.C. & Buthelezi, S. 2003. The closure of coal mines and local development responses in Coal-Rim Cluster, northern KwaZulu-Natal, South Africa. Development South Africa, Volume 20, pages 369-385.
- Bell, F.G., Bullock, S.E.T., Halbich, T.F.J. & Lindsay, P. 2001. Environmental impacts associated with an abandoned mine in the Witbank Coalfield, South Africa. International Journal of Coal Geology. Volume 45, Issues 2–3, January 2001, pages 195–216.
- Swart, S.J., Pulles, W., Boer, R,H, Kirkaldy, J. & Pettit, C. 1998. Environmental risk assessment as the basis for mine closure at Iscor Mining. The South African Institute of Mining and Metallurgy. January/February, 1998.

The publication of the country's only mining-related land rehabilitation guideline (Chamber of Mines, 2007) ten years ago, as well as the 2004 DMR Financial Provision Guideline (DMR, 2004) emphasise the above timeframe of a past mining-related rehabilitation focus. However, it is noted that much mining-related company-specific land rehabilitation research was actually undertaken during the 1980s (*pers comm*, Phil Tanner & Mark Aken, 2016). At one stage during this time, and even into the 1990s, Anglo American was seen as the leaders in the coal mining land rehabilitation in the country, with a dedicated environmental team responsible for suitable mine rehabilitation and closure planning and implementation. Unfortunately, very little of the sites' in-field research outcomes have been published, with most of this information either archived still in paper form, or 'within the heads of the gurus at the time' (*pers comm*, Phil Tanner, 2016). This appears to be the case with most of the global mining houses – information may be available, but it is not easily accessible and/or even documented or published.

When trying to find more recent published literature for the country, the following examples seem to dominate research search engines. This list, although just a snap shot of available literature, is notably shorter than that of published articles prior to 2007. Also, interestingly, much of the recent available literature seems to focus on mining's interaction between food security and/or socio-economic impacts. Both elements are key drivers of land use-, rehabilitation and closure planning.

- Albertsa, R. Wessels, J.A., Morrison-Saunders, A., McHenryd, M.P., Sequeirac, A.R., Mreghae, H. & Doepelf. D. 2016. Complexities with extractive industries regulation on the African continent: What has 'best practice' legislation delivered in South Africa? The Extractives Industries and Society. Online publication.
- Marais, L., Van Rooyen, D., Nel, E.L. & Lenka, M. 2015. Mine closure, the resource curse and Marikana flu: responses to mine downscaling in Matlosana and Matjhabeng.
- Chaminuka, P., Udo, H.M.J, Eilers, K. & Van deer Zijpp, 2014. Livelihood roles of cattle and prospects for alternative land uses at the wildlife/livestock interface in South Africa. Land Use Policy, Volume 38, pages 80–90.
- Limpitlaw, D. & Briel, A. 2014. Post-mining land use opportunities in developing countries–a review. The South African Institute of Mining and Metallurgy, Volume 114, November 2014, pages 899 – 903.
- Pijpers, R. 2014. Crops and carats: exploring the interconnectedness of mining and agriculture in Sub-Saharan Africa. Futures. Volume 62, pages 32 – 39.
- Brumfitt, I.M. 2013. Reconciling mining and land use planning law: challenges facing cooperative governance in South Africa. MSc Dissertation, University of Cape Town, 15 July 2013.
- Marais, L. 2013. Resources policy and mine closure in South Africa: The case of the Free State Goldfields. Resources Policy, Volume 38, Issue 3, September 2013, pages 363–37,
- Van Tonder, D.M., Coetzee, H., Esterhuyse, S., Msezane, N., Strachan, L., Wade, P., Mafanya, T., & Mudau, S. 2008. South Africa's challenges pertaining to mine closure-the concept of regional mining and closure strategies. Mine Closure 2008 – A.B. Fourie, M. Tibbett, I.M. Weiersbye, P.J. Dye (eds) © 2008 Australian Centre for Geomechanics, Perth, ISBN 978-0-9804185-6-9.

Local (municipal) requirements

From an urban land use planning perspective, the Spatial Planning and Land Use Management Act, No. of 2013 (SPLUMA) placed the management of local land use matters in the hands of the local government. The Act requires that each Local Municipality must, after public consultation, prepare, adopt and implement a land use scheme (LUS), (consistent with any existing Municipal Spatial Development Framework (SDF)) within five years of the Act being brought into operation (end-2018). Importantly, SPLUMA determines that the decisions of the local authority cannot be overturned at the national level except in the case of agricultural land.

Each Local Municipality is required to develop an overarching Integrated Development Plans (IDPs), aligned to the National Development Plan (NDP) objectives, which provides a clear strategic vision, goals and objectives of the municipality. A SDF is then required to give physical effect to the IDP's vision, goals and objectives (Western Cape Government Environmental Affairs and Development Planning, 2012).

From a mining perspective, the authorization for mineral rights remains at a National level, with the DMR. As highlighted by Brumfitt (2013), the approval for such a right is subject to decentralized provincial and municipal approval as well as national authorization, in accordance with cooperative governance. As per SPLUMA, land use zoning schemes are part of provincial and municipal planning mandates, and as such cannot be superseded by national government decisions. However, due to the nature of the South African economy and the contribution of mining to the gross domestic product (GDP), often is the case that the DMR is seen to dominate departmental debate and trump many other areas of legislation, development and administration (Brumfitt, 2013). With numerous court cases underway contesting the manner in which national departments overrule provincial and municipal mandates, the manner in which mining is granted as a viable land use in areas zoned for other uses is still to be seen. As is the effectiveness and ability of IDPs and SDFs to integrate local and district planning needs.

South Africa-specific guiding documents

Currently the South African Chamber of Mines/Coaltech "Guidelines for the Rehabilitation of Mined Land" (2007) is the only published guideline document available to the (coal) mining industry providing practical guidance on selection and implementation of feasible rehabilitation measures. Many major mining houses do, however, have their own in-house rehabilitation guidelines derived from international good practice standards in conjunction with experience obtained in-field when complying with legislative requirements.

Table 5 provides the key South Africa documents available to guide mining-related land rehabilitation, land use and closure planning.

Table 5: Summary of key South Africa documents available to guide mining-related land rehabilitation, land use and closure planning

Document	Date	Author		Relevance to land use planning
Guidelines for the Rehabilitation of Mined Land	2007	South African Chamber of Mines	National governing body	Only rehabilitation mining-related guideline in South Africa. Specific for coal-based strip-mining operations. Compilation of best practice at the time, as well as provides a basis

Document	Date	Author		Relevance to land use planning
				for how to achieve a sustainable usable condition of the land after mining. Places emphasis on the importance of identifying a suitable post-mining land use, and ensuring landform, soil and revegetation is aligned to the needs of this land use.
South African Mining Resources Administrative System (SAMRAD) Guidelines	2012 - 2004	Department of Minerals and Energy (now, DMR)	Regulator	Numerous guiding documents used to support applications for a mining right in terms of the MPRDA. Specifically, the Guideline for the Compilation of an EIA and EMP includes: • Need for a comparative land use assessment conducted in accordance with generally accepted principles of sustainable development by integrating social, economic and environmental factors into a comparison of the costs and benefits of the alternative land uses with those of the mining operation on an equitable basis.
Guideline Document for the Evaluation for the Quantum of Closure-Related Financial Provision Provided by a Mine. Rev 1.5.	2004	Department of Minerals and Energy (now, DMR)	Regulator	Provides a method for determination of financial provision for mine rehabilitation and closure. Was developed specifically for opencast coal mines, but is (incorrectly) applied by both industry and regulators to all commodities.

Corporate requirements

In addition to the above, while it is not specified that certification to a formal environmental management system such as ISO 14001 is required, de facto ISO 14001 is the system most commonly used in South Africa (CoM, 2007). Where mining companies adopt the ISO 14001 standard, maintenance and management and document control for rehabilitation activities are usually under control. This is because rehabilitation failure is one of the key environmental risks facing the operation and, therefore, must be fully addressed in Environmental Risk Register and Environmental Management Plan which are essential components of any ISO 14001 compliant system. For those mining entities that have not formally adopted the ISO 14001 system, there is a need to develop an in-house risk assessment and risk management system, with systems and protocols in place, maintenance and monitoring systems, and regular review of performance leading to correction of the system to eliminate non-conformances in respect of the rehabilitation risk. Whatever the protocol selected, good environmental management practice is underpinned by having good environmental management procedures in place and monitoring regularly to ensure that these procedures are fully implemented (CoM, 2007).

Aligned to the above, the following is evident within the South African mine rehabilitation, land use and closure planning context:

- South Africa has a plethora of well-written, up-to-date legislation governing mining mining-related rehabilitation and closure. However, in a country in which regulatory enforcement is severely lacking, and turnover of already inexperienced regulators is high, actual implementation towards successfully rehabilitated landscapes is improbable.
- This plethora of legislation often does not appropriately align as required, with varying requirements for different Departments. This creates an uncertainty as to whom the key regulatory authority is and with whom regulatory-industry relationships should be established.
- In addition, there is often an overlap in regulatory requirements, with mining companies required to submit numerous documents that could, in effect, be dealt with cumulatively. This duplication results in unnecessary time wastage of on-the-ground teams, as well as non-integration of vision, objectives and actions across all the documents.
- From an industry perspective, information may be available, but it is not easily accessible and/or even documented or published.

2.3.4 Global ‘regional’ mine closure planning

In areas dominated by mining, the need for a wider regional planning approach as opposed to site-specific plans has been coming to the forefront in the recent decade. Long-term water treatment and impacts on community livelihoods post-mining remain at the forefront of this regional planning drive. In South Africa, and most notably in the Witwatersrand Goldfields, and Mpumalanga Coalfields, interconnection of mine voids could result in premature closure of some mines that are dependent on the pumping infrastructure of other mines that are nearing decommissioning and/or have already closed. In addition, as noted by Van Toder *et al* (2007), ‘large complexes of mines within a single catchment area have a cumulative impact on their shared environment in such a manner that it is difficult or even impossible to apportion liabilities to a particular operation’. Concurrently, the development of ‘ghost towns’ along the Western Cape coastline due to closure of historic diamond mines, and the foreseen same issue fast approaching in the Mpumalanga Coalfields, for example, also drive the need for a more pro-active approach to the sustainable closure of mines in the country.

The above highlight how closure of one mine within a region can greatly impact on the ability of other mines to maintain operations.

In South Africa, the DMR acknowledged the cumulative extent of mining-related impacts on both the biophysical environment and social structures. The Department published a discussion document on sustainable development in the minerals sector (DMR, 2007) which included the need for development of regional mining and closure strategies. This document highlighted the need for mining activities to be integrated within the developmental plans of the region in which it is located, as agreed with regional stakeholders. From a sustainability perspective, these regional plans would assist not only in aligning economic contributions in a region, but also to prevent irreparable environmental and social damage to the region. Unfortunately, to date, only a Draft Strategy for Regional Mine Closure in the Witwatersrand Gold Mining Areas (DMR, 2008), has been published for industry use. And, even this document is poorly utilized by either regulators or industry.

In Australia, the 1996 Guidelines for Mining in Arid Environments (Australian DME, 1996) has a specific land use objectives' section focusing on a regional (Western Australia) post-mining land use of 'natural ecosystem and rangeland'.

Jones & Maclean (2013) note that reclamation in the oil sands within the USA and Canada has, to date, primarily examined landscape elements in isolation, and is only beginning to consider ways to integrate rehabilitation planning within the broader planning framework. Focus is being put on planning that includes all oil sands operators in a regional rehabilitation plan towards adequately addressing collaborative goals for future regional land use.

In Brazil, the mining company Vale has developed a regional closure approach for its iron ore operations (Resende, *et al*, 2014). The company's mines were delineated in terms of homogenous catchments, geological macro compartments (mining seams or areas) and geomorphic structures. The mines were then classified based on their size and corresponding level of employment within the region. Municipalities were also classified in terms of whether they were leading or supporting governance bodies, within either mining-specific or diversified economic bases. Importantly, the outcomes of implementing the regional planning approach were mainly positive, emphasizing the ability to create synergies between individual mine's socio-environmental programmes, improved site management, reduced operating and closure costs, simplified environmental licensing procedures, enhance stakeholder relations. More importantly, their regional closure planning has resulted in development of a 'master mine closure plan' for the entire territory (Picarelli, *et al*, 2014).

Incorporation of the final post-mining landform designs and environmental rehabilitation plans of all mines in the region, together with plans approved for surrounding urban areas, has also been a focus of the Vietnamese Research Association Mining and Environment (RAME), which was established in 2005. Specifically, this planning has highlighted that a coordinated, regional land use map is critical in guiding identification of plausible post-mining land uses, before the start of mining activities (Brömme *et al*, 2014).

2.4 Existing land use planning approaches

The following section highlights some approaches and concepts currently being used to guide and/or focus land use planning. Some of the approaches have been developed within a mining context, whilst others are underpinned by wider environmental or urban development planning drivers. However, each of the approaches discussed below have relevance to specific considerations that could improve planning and management of post-mining rehabilitated landscapes.

2.4.1 Planning driver

The following approaches highlight the importance of dedicated, focused upfront planning within the land use planning discipline. By gaining an understanding of legislative, socio-political and other planning needs, as well as an understanding of the land's capabilities pre- and post-mining, the better the ability of decision makers to identify challenges and opportunities towards creating a more sustainable landscape.

Mineral Resource Landscape

Guirco and Cooper (2012) define the '<u>Mineral Resources Landscape'</u> – a complex system linking minerals, metals and their sustainable use (Figure 4). The thinking is that management of the mineral resources landscape is highly dependent on the different ways people value and tolerate both positive and negative impacts. These impacts are associated with the intrinsic properties of each metal and of the ecosystems and cultures adversely effected across associated commodity cycles; the revenue generated and how it is used and who it benefits; and the ultimate 'service' offered by minerals when the metal is used in a final end-use application.

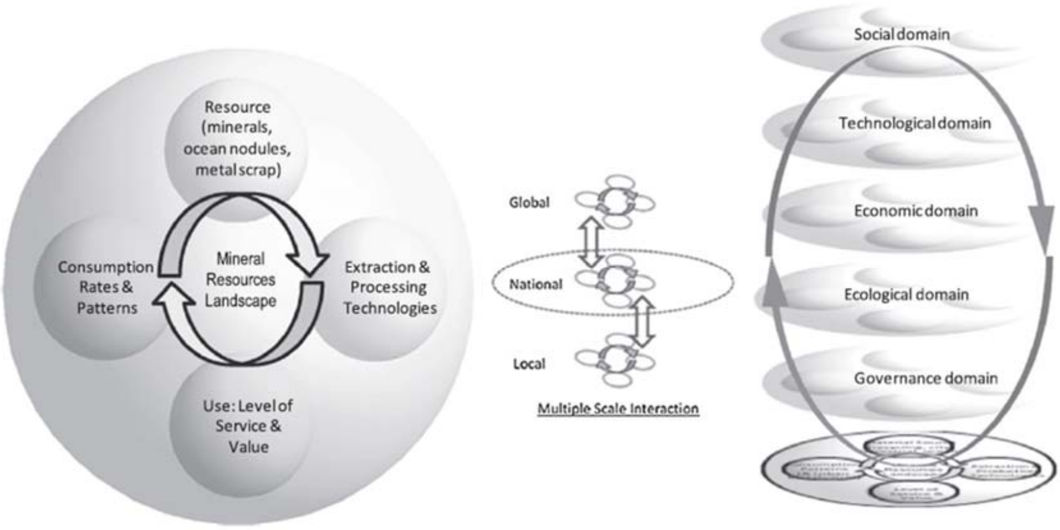

Figure 4: Mineral Resources Landscape approach (Guirco and Cooper, 2011)

The Mineral Resources Landscape identifies the following five interactive, dynamic domains against which sustainability performance can be measured:

- The *ecological domain* maps natural capital and represents resources in the natural environment and ecosystem processes;

- The *technological domain* encompasses innovation in technologies both for mining and in the way the system of minerals production and consumption and use operates;
- The *economic domain* includes financial capital (currency, shares, etc.), and also the economic systems which govern production and consumption and value of minerals;
- The *social domain* combines both social and human capital as well as localised political considerations; and
- The *governance domain* includes voluntary governance arrangements as well as legal and regulatory issues.

The intent of the 'landscape' is to provide a basis for better understanding of the present landscape and, through mapping issues and stakeholders across the landscape, scales and domains, to identify missing areas of focus and potential leverage points for a more sustainable landscape (Guirco and Cooper, 2012). (At the point of this research, no specific assessment criteria for the above domains have been developed to allow for the approach to be adapted to different contexts).

In China, Wang *et al* (2011) undertook a review of suitable evaluation methods of mined out land towards optimising rehabilitation outcomes. Although this is not the Minerals Resources Landscape approach, the process they defined has similar components (Figure 5). There is an upfront need to define policy and societal needs and requirements (*governance* and *social domains*), and to gain an understanding of the land's capabilities pre- and post-mining (*ecological domain*). Based on these, suitable land uses can be defined, towards conceptualizing an 'initial reclamation direction' (rehabilitation goal). Once this upfront context has been established, the most suitable rehabilitation methods could be defined.

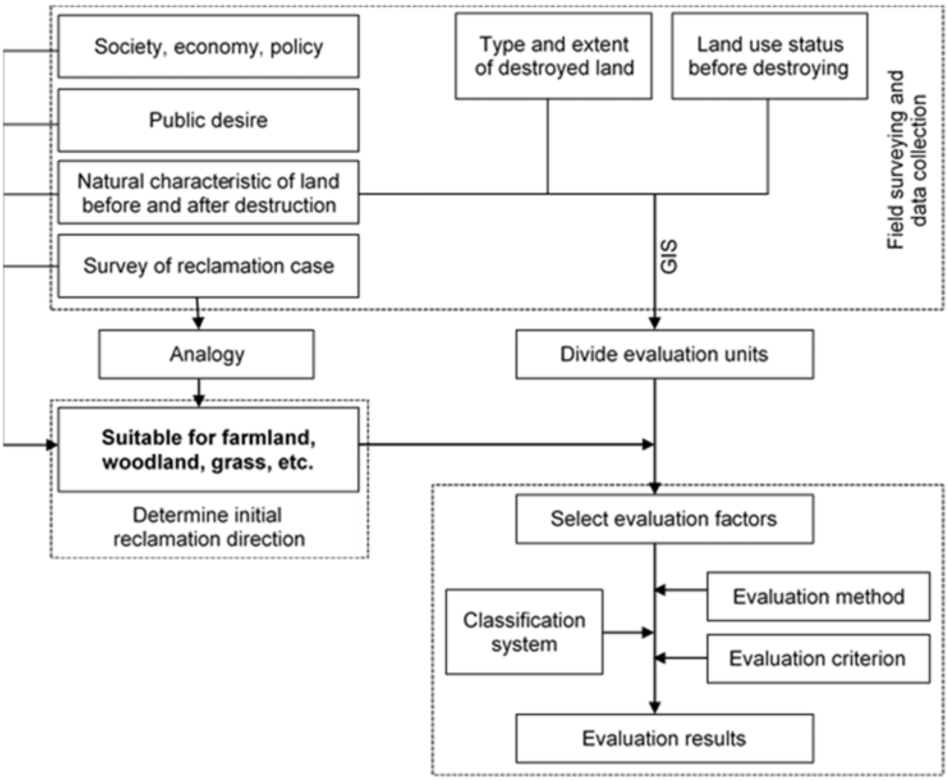

Figure 5: Process of suitability evaluation of mined out land towards optimising rehabilitation outcomes (Wang et al, 2011)

In addition, Sheng and Li-zhong (2009), documented the following key aspects that could assist in enhancing the post-mining land's use whist maximising socio-economic and environmental 'limitations':- 1) determining a strategy and goal for the post-mining land use – assuming implementation of basic national policy; 2) forecasting possible land use 'demand'; 3) planning the land's layout, and zoning accordingly; and 4) implementing the land use plan as part of the mine's rehabilitation strategy.

Similar to the Minerals Resources Landscape, both the above approaches require mapping issues and stakeholders *across the landscape, scales and domains*, towards achieving a rehabilitation landscape that is as holistically integrated as possible.

Ecological-economic zoning

The Food and Agriculture Organisation of the United Nations (FAO) utilize ecological- economic zoning (EEZ) (FAO, 1996) as a land use optimisation approach. This approach was initially introduced by Sombroek (2000), aim aims to:

- Identify areas where particular uses may be encouraged through development programmes, services, financial incentives, etc.;
- Identify areas with special needs and problems, as well as areas which require protection or conservation;
- Provide a basis for infrastructural development.

Ecological- economic zoning is, in principle, applicable to all geographic scales and for lands of any intensity of use.

Although EEZ is classified as a form of land use planning that considers all elements of the physico-biotic environment on the one hand and the socio-economic environment on the other, it's focus on infrastructure development (a social need) is dependent on the ability of available natural resources to deliver on these needs. It is also primarily used by planners that require outcomes to be executed through legislative, administrative and institutional action on demarcated spatial units (and hence its allocation within this 'planning driver' section.).

As an example, the EEZ approach has been applied in India. In the Yerrakalava catchment, in Andhra Pradesh, GIS-related information for physiography, irrigation, slope, soil depth, surface texture, ground water potential, production systems, population density, literacy percent and infrastructure were overlayed, and 42 zones mapped (Krishna *et al*, 2000). This enabled characterization of the area into areas of better physical resources, canal irrigation, high literacy percent and limited social conflicts, towards providing regulators with information to develop long-term land development opportunity policies in the areas.

2.4.2 Land capability driver

Land use planning relies on the capability of the land to provide specific ecological and human needs. The approaches highlighted in this section highlight that changes in natural resource patterns, or physical capabilities, affect what land uses can be implemented. Conversely, implementation of specific land uses affects the patterns and functions of remaining natural resources.

Land cover change

The Center for International Earth Science Information Network (CIESIN) at Columbia University, United States of America (USA) (www.ciedin.org) base their work on the understanding that global land cover change is an element of global environmental change. (Land cover here refers to physical, natural resources – i.e. the land's natural resource capability). Human systems generate changes both in land use and in the physical natural resource systems, and are thereby affected by the resulting changes in land covers; and vice versa. Figure 6 illustrates that a land cover (physical system) exists in a systemic relationship with human uses (land use) and the causes of those uses. Driving forces interact among themselves and lead to different land uses depending on the social context in which they operate.

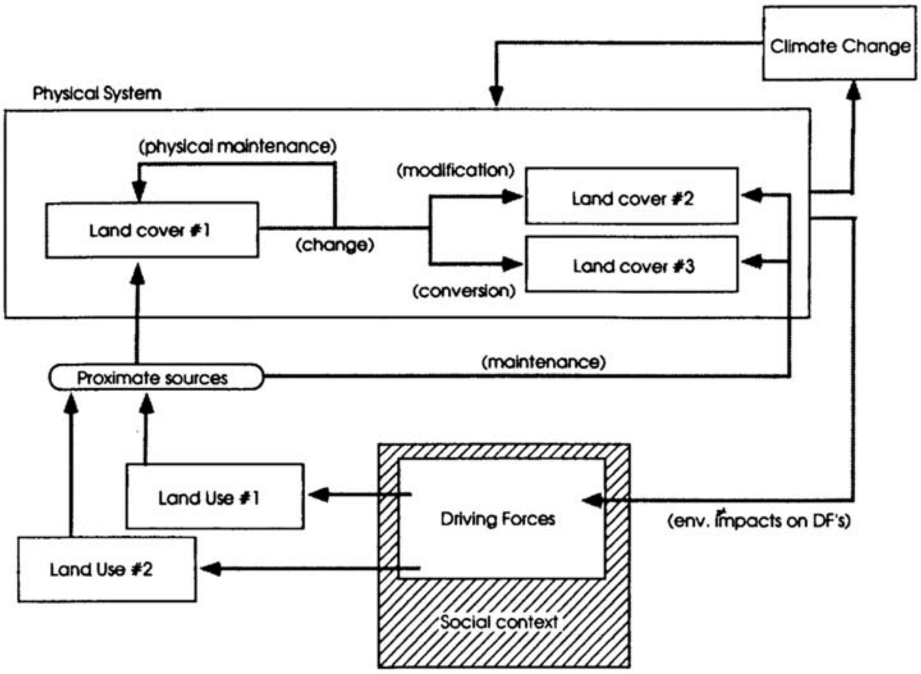

Figure 6: Land use planning approach focusing on land cover existing in a systemic relationship with human uses (land use), and the causes of those uses (CIEDIN)

As explained at www.ciedin.org, at time **t**, the underlying human driving forces lead to actions precipitating demand for Land Use #l which requires the manipulation of the land cover by means of technology employed in human activities such as clearing, harvesting, or adding nutrients. This manipulation is directed either to changing the existing land cover (#1 to #2 or #3) or to maintaining a particular cover (#1). In the former, the existing cover is changed to a new state that must be maintained in the face of natural processes that would alter it (physical maintenance loop). Changes to a new state of land cover are of at least two kinds: modification as in land cover #2 (e.g., fertilisation of farmland or planting exotic grasses in pastures) and conversion as in land cover #3 (e.g., forest to farmland or dryland to irrigated agriculture). Maintenance processes sustain the land-cover conversion (#3) or modification (#2). Therefore, proximate sources can be seen as those of conversion, modification, or maintenance.

The environmental consequences of uses of land cover (changes in the state of cover) affect the original driving forces through the environmental impacts feedback loop. Likewise, these land-cover changes (#2 and #3) can be repeated elsewhere such that they reach a global magnitude that triggers climate change, which, in turn, feeds back on the local physical system, affecting land cover and, ultimately, the driving forces through the environmental impact loop. Regardless of the stimuli - local or global environmental impacts or the interaction of the driving forces in their social context - changes in driving forces at time t2 may trigger a new land use (#2), with new consequences for the land use/cover system (www.ciedin.org).

This approach appears to have been developed with the overarching concept of global environmental change in mind. However, it highlights that changes in natural resource patterns and functions (i.e. land's physical capabilities) affect what land uses can be implemented. Conversely, implementation of certain land uses affects the patterns and functions of remaining natural resources. Importantly, it emphasises that natural resources can be converted and modified, based on human needs (or, desired land uses), but that the maintenance of these altered landscapes has a significant impact on the land's capability to continue to provide its pre-altered goods and services.

In some Chinese provinces, the mining-related land use plan is underpinned by the concept of land utilization, which can be correlated with the above land use/cover approach. Assuming underlying socio-economic development and environmental improvement drivers are considered, the understanding is that only a land utilisation system which combines the essential biophysical capabilities of the land within a defined 'strategic arrangement' can achieve a successfully rehabilitated, functional mine site (Sheng & Li-zhong, 2009).

From a mining perspective, the above implies that the more land capability options provided by the rehabilitated landscape, the more options available for actual use of the land over time. A defined mixed suite of land capabilities could offer more possibilities for a mixed suite of land uses, as opposed to only one or two uses which is the commonly adopted approach for South African mining houses. (This is aligned to most EMPs committing to the same or similar post-mining land uses as the pre-mining landscape, which was often arable land). It further implies that active land management of the rehabilitated landscape becomes an integral component of demonstration of successful rehabilitation – without this active management, the rehabilitated landscape could be further converted or modified by the human or animal land users, thereby altering or modifying the rehabilitated land's capabilities and associated uses. Although active land management suggests some degree of adaptability over time and space – landscapes are living, changing systems and large variances from the initially planned rehabilitated goal could affect eventual site relinquishment to a new land owner.

Ecosystem services

Although a wealth of information is available on land cover change, both in the form of current vegetation maps and as scenario-based projections, few tools exist for translating this information into relevant indicators of EP (ecosystem properties) or ES (ecosystem services) provision (Diaz *et al*, 2007).

However, the Millennium Ecosystem Assessment (2005) formally defined 24 types of ES and associated indicators. Different land use patterns provide a specific range of ES according to the intensity of use and the proportion of virgin landscapes (Larondelle & Haase, 2012). So, ES are assumed to serve as landscape assessments, evaluating the individual parts (e.g., field plots, landscape elements or compartments) and functions (e.g., production, retention or information) demarcated by different users. Hence, the attractiveness of ES is based on the integrative, interdisciplinary and transdisciplinary character, linking environmental and socio-economic aspects by involving both natural and social scientific perspectives and approaches (Lupp *et al*, 2014).

Based on the above, it seems appropriate to apply the ES landscape assessment approach to highly dynamic landscapes, such as changing mining areas.

Using the historical Leipzig opencast lignite mining area in Eastern Germany as a case-study, Larondelle and Haase (2012) identified specific ES based on mining's known primary landscape impact aspects - soil, soil functions, and water regimes. The ES were food production, fibre production, fresh water provision, climate regulation, flood regulation and primary production. They also included recreation – considering that many mining areas are in close proximity to human settlement areas, and biodiversity – based on the fact that biodiversity protection remains a global initiative. The study highlighted that it 'is not practical or possible to restore nature or ecosystems that existed in the pre-mining rural landscape; instead, one can identify future land use solutions that provide places to live, produce food, and supply recreational areas or that can mitigate climate change" (Larondelle and Haase, 2012).

2.4.3 Integrated ecological/sociological/economic- driver

Although the approaches identified above have core planning- or land capability/ecosystem drivers, almost all the existing land use approaches being used globally (including those above) understand the need for integration across planning domains. The approaches highlighted below mostly used a land suitability analysis concept which is used to generate and evaluate alternative future scenarios depicting how landscapes are likely to develop under varying assumptions and conditions. Although Land Suitability Analysis (LSA) can be used for a single landscape component or interaction amongst multiple components, its strength is in the spatial integration of biophysical, socio-demographic and economic information.

Land suitability analysis

The process of determining the suitability of a given piece of land for a defined use is named Land Suitability Analysis (LSA) (Mu, 2006). It enables identification of the most appropriate location and distribution of future land uses (Malczewski, 2004). Various layers of spatially referenced, superimposed information about selected characteristics of a region can be analysed collectively. This provides a cumulative assessment of a location's qualities that is useful in making decisions about its future use. Its applicability to planning-related fields stems from its ability to assist decision makers in formulating policies about site-specific development proposals, their environmental impacts and their potential cumulative effects over time (Collins *et al*, 2001).

Since its inception in the 1950s, LSA frameworks have been used and/or modified globally in land evaluation processes. It used in a wide variety of settings - ecology for defining habitat suitability, agriculture for crop suitability, landscape architecture for site analysis, and environmental sciences where impact assessments may be required (Malczewski, 2004).

Land Use Conflict Identification Strategy

The Land Use Conflict Identification Strategy - LUCIS, was developed at the University of Florida's Department of Urban and Regional Planning, and is based on the concept of LSA. It is also underpinned by the Compartment Model comprising the following four general land use types in a simplified model "so that growth-type, steady-state, and intermediate-type ecosystems can be linked with urban and industrial areas for mutual benefit." (Odum, 1969):

- Productive areas: "…where succession is continually retarded by human controls to maintain high levels of productivity";
- Protective areas: "… where succession is allowed or encouraged to proceed into the mature, and thus stable, if not highly productive stages";
- Compromise areas: "…where some combination of the first two stages exists"; and
- Urban/industrial / biologically non-vital areas.

Odum (1969) noted that that by dividing land use into these categories, and "by increasing and decreasing the size and capacity of each compartment through computer simulation, it would be possible to determine objectively the limits that must eventually be imposed on each compartment to maintain regional and global balances in the exchange of vital energy and materials."

The University of Florida equated the above four areas to the following in LUCIS: productive = agriculture (land that produces food, fuel or fibre); protective and compromise = conservation (environmentally significant land), and urban/industrial = urban (land supporting relatively intense human activity – residential, commercial, industrial) (https://www.geoplan.ufl.edu/lucis/aboutus.html).

Ultimately, the results of a LUCIS model help identify areas that are highly appropriate for future urban development, areas that should be set aside for conservation, and areas that should be set aside for agricultural production.

The LUCIS model appears to be widely used within the United States of America (possibly due to its development in Florida), with the following examples highlighted from the literature review. (It is noted that most of these references are web-based, due to their outcomes having been published as spatial / geo-referenced data).

- Alternative future scenarios for South-West Florida, University of Florida – (https://www.geoplan.ufl.edu/lucis/swflorida.html);
- East Central Florida 2050, University of Florida – (https://www.geoplan.ufl.edu/lucis/myregion.html);
- Florida 2060, University of Florida – (https://www.geoplan.ufl.edu/lucis/1000friends.html);
- Heartland 2060, University of Florida (www.cfrpc.org);

- Identifying potential future land use conflicts in North Central Florida (Carr & Zwick, 2005);
- Identification and analysis of future land use conflict in Mecklenburg County, North Carolina (Cotroneo, 2015).
- GIS model for the land use and development master plan in Rwanda (Tims, 2009).

Mined Land Suitability Analysis

The Mined Land Suitability Analysis (MLSA) framework, based on the LSA frameworks, was developed on the premise that as the post-mining land use prescribes the methods, measures and costs of mine rehabilitation, a major implicit goal of mine rehabilitation should be to determine an appropriate after-use option (Soltanmohammadi *et al*, 2010). The MLSA is an analytical approach (using a combination of two Multi-Attribute Decision-Making (MADM) techniques) applied to try optimise the determination of this post-mining land use. Upfront identification of possible project land use alternatives were categorised into economic, social, technical, and mine site factors, with the ultimate goal being mined land suitability (Figure 7).

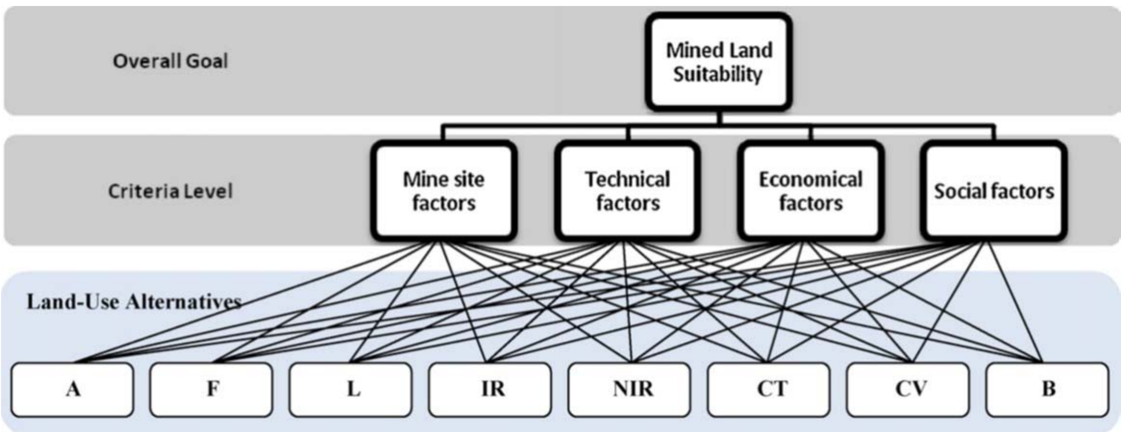

Figure 7: Hierarchical structure of the MLSA fifty-attribute framework (Soltanmohammadi *et al*, 2010)

This approach highlights the complexities of land use planning within the mining context – the use of MADM techniques such as the Analytical Hierarchy Process (AHP) immediately implies the

Alternative futures modelling

During 2014, the Maine Futures Community Mapper was developed in partnership between the University of Maine, the Center for Community GIS, and over 75 Maine citizens, planners, conservationists, business leaders, foresters, farmers, and scientists in the USA (http://www.mainelandusefutures.org/modeling-approach/process-overview/). The project was undertaken to manage land fragmentation resulting from changing land ownership patterns and rising urban development pressures taking place in Maine over the past roughly 20 years. This resulted in the fragmented urban landscapes becoming less available to traditional uses such as recreation and forestry.

The team understood that communities, planners, businesses, advocacy groups and others often lack the time and resources needed to identify and evaluate the impacts of important land use decisions. These limitations often mean that important decisions regarding land use are made with incomplete information regarding current and future conditions. As a result, approaches that can integrate spatial data with expert knowledge have the potential to improve land use decision-making processes for practitioners, policy makers, and the public (Lilieholm *et al*, 2012).

The Mapper is underpinned by the concept of 'alternative futures modelling', which is an analytical framework that spatially integrates biophysical, socio-demographic and economic information into a GIS-based system of simulation models that can be used to assess the impacts of land use policies on a variety of social, cultural and natural features (Lilieholm *et al*, 2012). Basically, similar to LUCIS, it is underpinned by the concept of land use suitability analysis. Accordingly, the models are used to generate and evaluate alternative future scenarios depicting how landscapes are likely to develop under varying assumptions and conditions. The models may focus on single components of a landscape, such as water resources, or the interaction among multiple components, like urban development and the loss of agricultural lands or sensitive species habitat (Hunter *et al*, 2003).

The Mapper has been effective in informing stakeholders about the potential consequences of alternative land use futures, and has helped foster proactive land use planning that protects both human and natural systems. Ultimately, identifying a plausible range of future development scenarios has been noted as being critical in developing and evaluating the likely effects of alternative land use policies for the region.

Econometric-based landscape simulation models

In landscapes dominated by private ownership (such as the Mpumalanga Coalfields), landowners lack the incentive to coordinate decisions to influence the spatial land use pattern and the environmental outcomes that depend on it. Econometric-based landscape simulation models have been developed to understand the nature and extent of this pattern-outcome problem and to identify and quantify the effects of corrective land use policies (Plantinga & Lewis, 2014).

A landscape simulation begins with a spatial representation of the landscape, such as a land use map where the unit of analysis is a land parcel, and simulates changes in the landscape through the use of rules applied at the unit scale. An econometric-based simulation model uses rules derived from econometric estimation. The econometric results are then incorporated into a landscape simulation model used to study how, for example, forest fragmentation is affected by incentive-based policies that modify the relative returns to different uses (Plantinga & Lewis, 2014).

The importance of econometric-based landscape simulation models is that they can be used to predict how current land uses can affect development of new land uses in these and adjacent areas, based on economic supply and demand of a specific land use within an area. For example, demand for urban development is underpinned by proximity to central business districts, roads, schools, amenities, etc., as well as by spatial interactions with adjacent, neighboring land uses. Concurrently, returns to rural land uses, such as agriculture and forestry exhibit little variation on economic land returns due to output and input prices for land-based commodities being relatively constant over time and space. However, this can vary when considering soil quality and access to markets. In addition, stringent or restrictive land use regulations such as zoning restrictions can limit economic returns for a particular land use.

For the purpose of this study, it is evident that identification and understanding of adjacent land uses to the mining property becomes critical in assessing economically viable options for the rehabilitation mining land. Mines in close proximity to urban hubs have the potential to consider integration of their rehabilitated sites with further urban development plans. Mines located within rural/farming environments would benefit from fitting into needs for land-based commodities. Ultimately, rehabilitated landscapes should consider opportunities for integration within existing or planned regional, cross-boundary land uses. The demand and supply from these existing land uses will also guide the potential economic return the rehabilitated landscape will be able to provide the mining company.

Pressure-state-response models

Lei and Hui (2011) modified the pressure-state-response (PSR) model to reflect a conceptual framework for assessment of the impact of mining on future land use/s - basically, an ‘assessment index of land use security’ (Figure 8). This framework was used to assess the current land use changes of mining-affected land in Wu’an, in the Hebei Province, based on the comparison of 1996 and 2008 data.

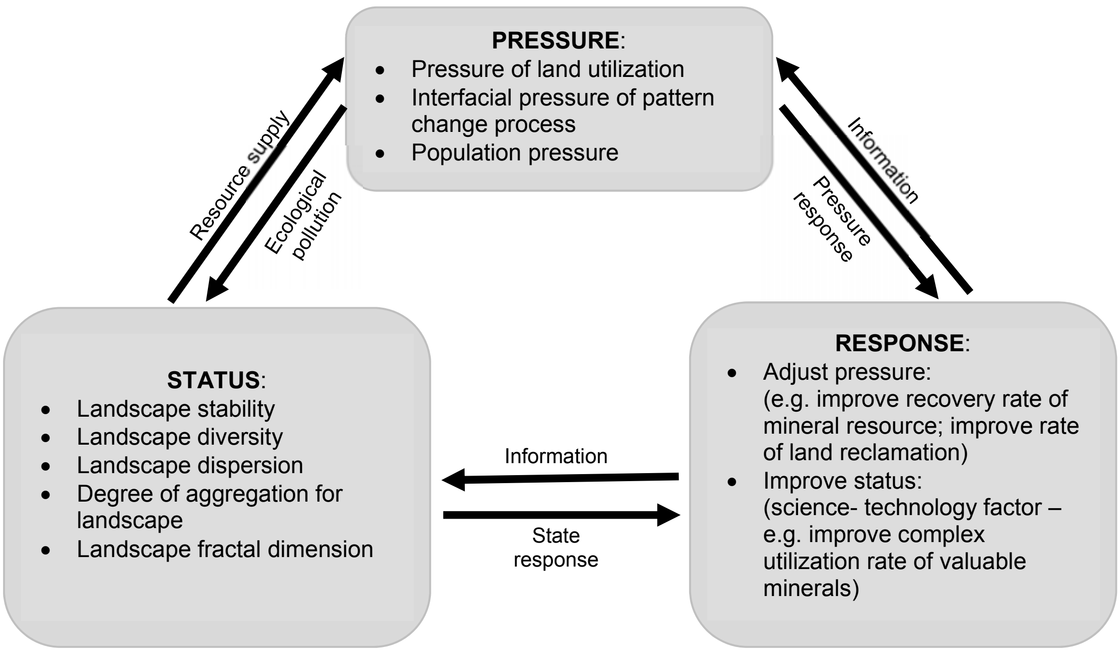

Figure 8: Conceptual framework of assessment index system for land use security (adapted from Lei & Hui, 2011)

A target (A), criteria (B) and index (C) layer system was then determined (Table 6), and each factor was compared using the Analytical Hierarchy Process (AHP) analysis and weighting method (Lei & Hui, 2011).

Table 6: Combined assessment index system of land use security pattern in mining (Lei & Hui, 2011)

Target layer (A)	Criterion layer (B)	Index layer (C)
Pressure (A1)	Population pressure (B1)	Population density (C1), 1 person/km^2
	Land utilisation pressure (B2)	Disturbance strength index (C2), mining land area/total land area (%)
	Pattern pressure (B3)	Integrity of natural framework (C3) Ecological network integral pattern changes caused by mining (%)
	Progress pressure (B4)	Integrity of the natural process (C4) Land area with ecological value/total land area (%)
	Interfacial pressure (B5)	Extensibility of natural interface (C5) Length of mining land interface/total length of interface (%)
	Ecological pressure (B6)	Ecological footprint (C6)
Status (A2)	Landscape stability (B7)	Landscape diversity (C7)
		Landscape dispersion(C8)
		Landscape aggregation degree (C9)
		Landscape fractal dimension (C10)
Response (A3)	Adjust pressure (B8)	Mineral resource recovery rate (C11) (%)
		Land reclamation rate (C12) (%)
	Improve status (B9)	Rate of multi-purpose utilization of mineral resource (C12) (%)
		Science-technology input (C14) Investment in rate of environmental governance (%)

Importantly, the approach enabled identification of the following key aspects for mining-related land use change, from a PSR perspective (Lei & Hui, 2011):

- Reduction in the overall regional 'pressure' exerted by the mining operations resulted in the land 'state' improving;
- Increasing focus on good corporate governance with regards to managing environmental impacts and the rehabilitation process throughout mining resulted in an increased

contribution of the 'response' mechanism to supporting functional post-mining land use/s; and, conversely,

- Although a focus on rehabilitation resulted in an improved chance of achieving successful land use recreation, the cumulative effect of the mining operations could not be totally mitigated in the regional context. In other words, the rehabilitated post-mining land could not provide 100% of the land capabilities required to recreate the land use/s of the pre-mining environment.

The above PSR approach provides a mechanism to assess the ability of a mining operation to create functional post-mining landscapes. This will depend on the manner in which the operation exerts and manages its landscape pressures, as well as how it provides appropriate 'responses', or mitigation measures. Critically, it talks to the need for a wider, regional approach to rehabilitation of mining areas, not only at a site-specific level, towards capturing sufficient footprint areas to recreate pre-mining landscape functionalities.

2.4.4 Role of geographic information systems

Mining, throughout the process of extraction, rehabilitation and monitoring, is directly dependent on natural resources. Accordingly, as a user of natural resources, mining should ensure the sustainable use thereof in order to achieve production, rehabilitation and post-closure targets, and the maintenance thereof.

A prerequisite to achieve this is access to accurate, reliable and relevant geo-referenced information. Spatial information systems allow for the integration of various sets of data, assisting users in the reaching of conclusions on a specific matter (Collept & Lindemann, 2006). Accordingly, the use of computer models as part of the land use planning process has become more common in the past two decades as readily available geographic information system (GIS) software programs have become more accessible, affordable and user-friendly (Heartland2060, undated). By overlaying data relevant to specific topics – biodiversity, water, urban settlement, etc., areas with commonalities and/or key importance for the design criteria become evident. For land use planning, which requires integration of numerous disciplines, GIS-based decision-support systems can provide a mechanism to 'sift through the chaos' towards improving uncertainties in the decision-making process. Most of the case-studies within the literature review utilised some form of land suitability analysis with GIS support (Straume, 2014; Wu *et al*, 2011; Antwi *et al*, 2008; Sutton *et al*, 2006). In addition, in support of the GIS, where evaluation of various opinions or sets of similar data were required, weighting tools such as the AHP of Bayesian belief networks (BBNs) were seen to be preferred (Wu *et al*, 2011).

However, it is noted that GIS software and its decision-support capabilities are only as good as the data used to inform the software. In the mining industry, data from studies required to inform natural resource planning is often provided in a format decided upon by the specialist team. This results in inconsistencies in software across specialist studies, which limits the mines' ability to consolidate the data. Furthermore, most mining houses only focus studies within their mining rights' areas and, even if specialist data is provided in the same format, this results in lack of knowledge of up- and downslope systems that could either be impacting on the mine site, or being impacted upon, by the mine site. Hence, planning becomes restricted and geographically confined. Finally, even if appropriate date is available, covering larger footprint areas, often the consolidated data requires an integrated team to analyse its site relevance.

Within the South African 'environmental planning' field, the importance of GIS-based data to inform natural resource management, and to assist larger industries such as mining in dealing with the data inconsistencies mentioned above, is clear. Over the past decade, a plethora of GIS data has become publicly available by key national research institutes. Although some of this data is not necessarily at the land scale (i.e. it has been ground-truthed for accuracy), its availability has helped provide suitable, scaled data to assist land practitioners in making appropriate land-related decisions. The following highlights some of the key data sets available in South Africa:

- South African National Biodiversity Institute (SANBI) biodiversity GIS (BGIS) (www.bgis.sanbi.org) – acts as a central hub for the management and dissemination of biodiversity planning and related information. Provides data as interactive maps, accessible via free tools to view and analyse available spatial data.
- As part of the SANBI BGIS, there is a dedicated land use decision support (LUDS) tool (http://bgis.sanbi.org/LUDS/Home) – intended to assist environmental practitioners by providing them with a tool that extracts the most important biodiversity planning information for an area from national and regional spatial datasets. This facilitates their decision-making processes when assessing the possible impacts of development or land use change.;
- Department of Environmental Affairs' (DEA) environmental GIS (EGIS) (www.egis.environment.gov.za) – provides access to baseline environmental geospatial data and services, and includes a register of South African protected areas and national land cover data sets.
- Department of Agriculture, Forestry and Fisheries' agricultural geo-referenced information system (AGIS) (www.agis.agric.za) – aimed at providing a one-stop service for the agricultural sector, providing access to spatial information (maps), industry-specific information and decision-support tools.
- Water Research Commission (WRC) South African mine water atlas (www.wrc.org.za) - intended to map the unmitigated threat of mining to South Africa's water resources. Provides consolidated (somewhat fragmented) existing data pertaining mostly to mineralogy, water quality, flow, present ecological state, hydrogeological information, to provide a national overview of what is happening across the country.

As summarized by Jones & Maclean (2013), the scale of disturbance and complexity of building entire landscapes will require modelling to allow planners to examine optimized land options, in conjunction with thoughtful research designed to critically evaluate these potential options.

2.5 Mining-related land use challenges and opportunities

Barkemeyer *et al* (2015) use the term 'wicked problem' to describe situations that are highly challenging, contradictory in nature and dynamic; 'they also suffer a lack of clarity in terms of a route towards an optimal solution'. Post-mining land use planning epitomises a 'wicked problem' in that it requires consideration and integration of ecological, social, political, cultural and economic drivers which operate over varying temporal and spatial scales. These drivers need to be aligned with the expectations of numerous stakeholders that either impact on the landscape and/or will be affected by its long-term land capability and use. These expectations are often defined by corporate-specific core values that vary between achieving minimum regulatory requirements (compliance) versus those that aim to achieve international best practice (stewardship). Further complications arise with the plethora of scientific disciplines required to define and continually asses the post-mining land capability as well as regulation by the often unattainable local and national legislative policies that are meant to guide overarching site-specific planning.

This section highlights key aspects that have been identified in available literature that motivate the need for dedicated land use planning as part of mining-related rehabilitation and closure planning and implementation.

2.5.1 Reconciling national, regional and local planning

A critical challenge for land use and management involves reconciling conflicting national, regional (municipal) and local (site-specific) goals and uses of the land by all stakeholders into the future. Local and regional perspectives on the benefits and costs of land management also exacerbate the difficulty of these decisions (Dale *et al*, 2000).

Lane and Ndlovu (2012) have noted that expectations on the land from regulators, industry and communities surrounding mining areas can vary greatly and, in the end, a compromise suitable to all stakeholders will never be fully possible. They devised Figure 9 which clearly indicates how desires on a mining operation can significantly vary, as well as the way challenges arising from expectations not being met can manifest. This figure highlights often incompatible requirements on the land, emphasizing that reconciling conflicting national, regional and local land use goals is a highly complex issue facing mining-related land use planners.

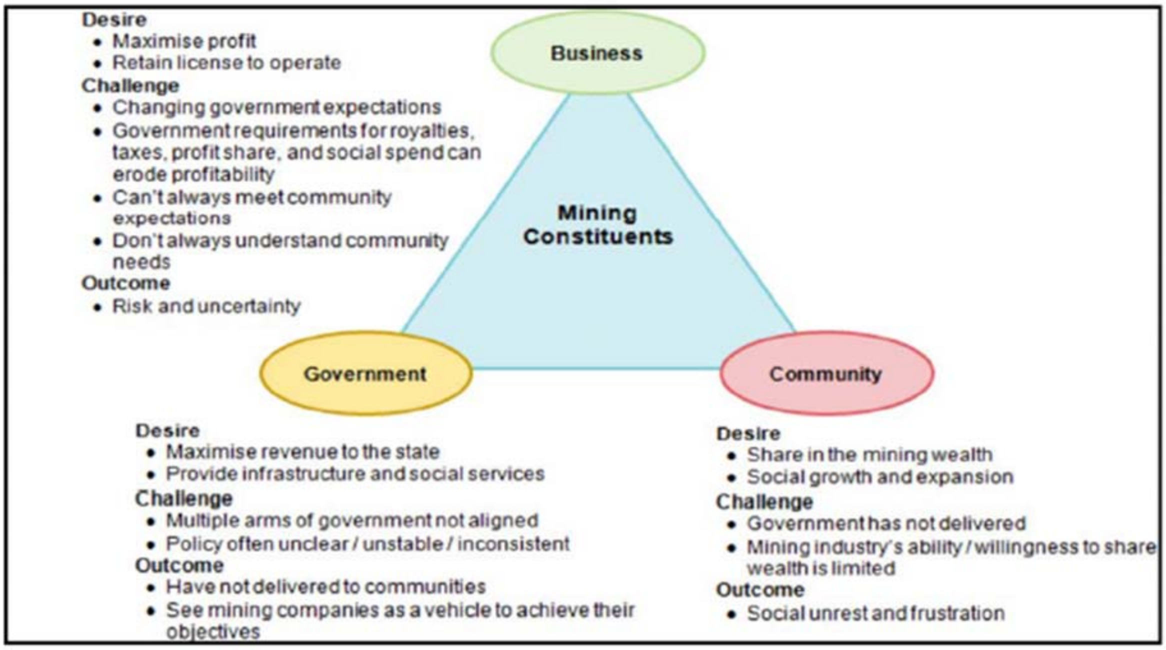

Figure 9: Varying stakeholder desires on mining land (Lane & Ndlovu, 2012)

Using the UK as an example, Bloodworth *et al* (2009) note that the regulatory framework in which mineral extraction operates in the UK has a profound impact on land use. Spatial planning policy decisions made in one part of the country have unintended consequences elsewhere. However, network analysis and other modelling techniques have allowed the economic, environmental and land use consequences of policy decisions related to the supply of minerals to be simulated ahead of implementation.

Hence, readily available and nationally-consistent land use planning is needed to guide preparation for and achieving productive landscapes and prosperous regional communities based on sustainable natural resources use.

2.5.2 Integrating land use- and mine planning

Warhurst and Noronha (2000) identified that the attractiveness of the concept of planning for mine closure as a life-cycle approach to managing the mining-related environmental impacts, is rooted in what may be referred to as the time factor. The greater the time lapse between the occurrence of environmental damage and its remediation, the greater (in most cases) will be the resources (both human and financial) needed to address the problem. In the absence of adequate rehabilitation and closure planning, the demand for financial resources to complete the closure process will occur at a time when the firm is experiencing a reduction in cash flows.

Stacey *et al* (2010) further contend that land use planning must evolve throughout the life of the mine, and needs to be reviewed to fit within developmental, ecological, social, and political imperatives as these change. Valid closure goals can be set only in full consultation with those affected by the operation. The Vietnamese RAME notes that successful implementation of the post-mining land use plan needs well-coordinated management, especially as this is a task easily lasting 20 to 30 years. The implementation includes measures during the ongoing mining activities and after mine closure as several decisions (for instance on the final morphology) must be made in a very early stage (Brömme *et al*, 2014).

Most mining assets, due to their highly specialised nature, are not often viewed as potential non-mining assets in a broader context and are therefore seldom retained or transferred to a third party for beneficial re-use (Murphy *et al*, 2007). However, re-using mining assets, either *in-situ* or elsewhere has several inherent advantages. The cost of establishing new industries and land use activities may be partially or even largely avoided, as future users utilise what is already there. The use of large amounts of raw material and the environmental impacts associated therewith is also eliminated. Furthermore, this approach helps to retain the visual character and sense of place of an area by allowing the 'temporal layering' of the cultural landscape to occur, as opposed to a 'clean slate' approach which effectively removes most traces of previous land uses.

By incorporating land use planning as an integral component of mine planning, the suitability of the mine plant, infrastructure, associated rehabilitated facilities (such as waste rock dumps and back-filled pits), as well as surrounding land within the mining rights boundary, can be assessed for specific characteristics that could either enhance or impact on the next land use. This could include assessing the suitability for use, safety, potential for environmental impact and the associated cost of retrofitting the specific mining assets for future use. It also would consider most suitable placement of infrastructure and location of long-term landscape components such as final voids or hazardous waste facilities. It is likely that not all assets will be fit for purpose for the next land use, and some expenditure will be required to either renovate or refurbish the asset prior to re-use or transfer. In this regard, the possibility of future mining and/or re-processing opportunities either on-site and within the greater regional operations, and the possible extended use of existing infrastructure could also be considered.

In addition to the above, critical to the success of eventual land ownership transfer are the appropriate due diligence assessment and understanding of potential environmental and health liabilities generated from the rehabilitated land. In the case of new mines or mines that are planning to expand, once a next land use has been defined, it would be useful to identify potential buyers or beneficiaries and forge agreements for asset transfer at an early stage rather than having to search for potential end users near the end of the life-of-mine. This could help prepare the mine to reduce potential future legal, financial and logistic requirements that could make the re-use of infrastructure and rehabilitated land ultimately unfeasible.

The relevance of incorporating land use planning upfront in mine planning is especially evident in the event of unscheduled (unplanned) mine closure. The ability of the mine to achieve a more desirable post-mining state should already have been secured during operations. However, during unscheduled mine closure most decisions need to be taken and executed rapidly, which leaves little 'maneuvering room' to accommodate potential next land uses that have not been anticipated or planned for.

In terms of the above, in instances where potential post-mining uses of mining infrastructure and rehabilitated facilities are identified up-front as part of the mine planning, some of the associated costs could be incorporated within the initial mine design. This could significantly reduce potentially prohibitive costs at a later stage, when the mine is already having to spend large amounts of money in other areas of closure-related work.

2.5.3 Managing residual and latent rehabilitation risks

Impacts of land use decisions can, and often do, vary over time. Long-term changes that occur as a response to land use decisions can be classified into two categories: delayed and cumulative. Delayed impacts may not be observed for years or decades, with cumulative effects being illustrated by events that together determine a unique trajectory of effects that could not be predicted from any one event (Paine *et al*, 1998).

Aside from the obvious biophysical impacts posed by a mining, previously mined areas can also pose several long-term risks. These can be *residual risks* which will likely remain post-rehabilitation and require management into perpetuity, or *latent risks* which manifest in the rehabilitated landscape over time, often many years after site decommissioning. These have obvious restrictions on adequate implementation of identified next land uses.

Examples include potentially unsafe surface structural conditions as well as alteration to surface hydrological regimes associated with underground mining methods due to surface subsidence, goafing and/or sinkhole formation; surface expression or decant of poor quality underground water; acidification of placed topsoil due to underlying acid-generating waste material resulting in ultimate die-off of established vegetation; structural stability, settlement and changes to surface topography of backfilled open pits and rehabilitated dumps. Inappropriate use of previously mined areas may also result in water pollution, the large-scale infestation of alien invader plant species; or even highly dangerous conditions such as spontaneous combustion at old coal mines.

Already in 1998, Swart *et al* (1998) provided the following schematic approach to risk assessment (Figure 10). This approach was adopted at the South African Durban Navigation Collieries (Durnacol) to try provide a process capable of giving the necessary confidence to regulators that the mine has accurately predicted its long-term (+100 years) impacts, and hence has made the necessary resource and financial provisions to address the impacts.

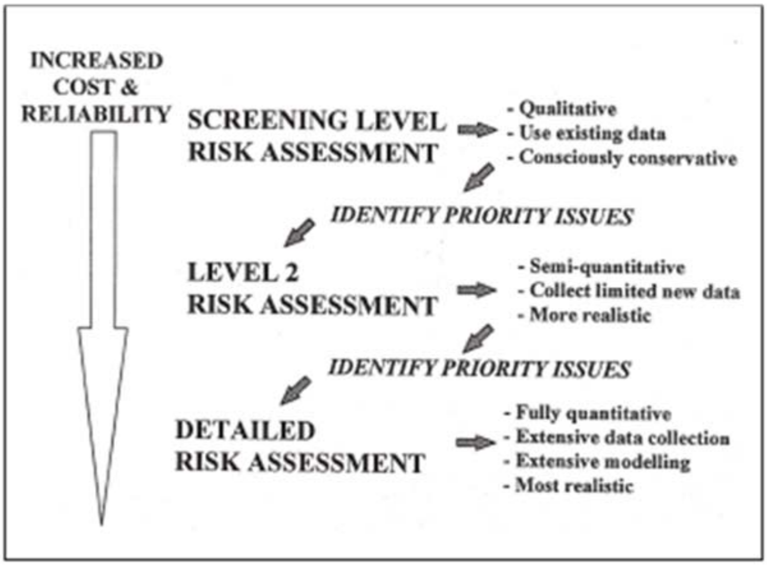

Figure 10: Schematic approach to risk assessment (Swart *et al*, 1998)

Simply put, the above figure indicates a need for increase in site knowledge as a company moves from a screening level risk assessment (RA), to a Level 2 RA and finally to a Detailed RA. In addition, the level of certainty of the probability of a risk occurring should also improve, together with the focus on the rehabilitation measures required to address the risk. Ultimately, a screening level RA provides an opportunity to identify probably site risks for conceptalising suitable rehabilitation measures, and the Level 2 RA initiates quantification of data to start informing whether or not the rehabilitation measures are working or need amendment. By the time a Detailed RA is needed, enough long-term data should have been accumulated to inform long-term management measures. It is usually the residual and latent risks still remaining in the Detailed RA that would require long-term management post-closure. And it is usually these residual and latent risks that could continue to impact on the functionality of the implemented next land use.

The South African NEMA GNR1147 Regulations promulgated on 20 November 2015 (DEA, 2015), requires that mines need to submit an annual environmental risk report (ERR), which "must contain information that is necessary to determine the potential financial liability associated with the management of latent environmental liabilities post closure, keeping in mind the proposed post-mining end use, once the initial relinquishment criteria have been achieved". Although this specific legislation is relevant to the mine *closure* planning scenario, it builds on the DEA NEMA mine *planning* legislation which required qualification of construction, operational, decommissioning and closure site risks when applying for a mining authorisation. Of relevance is the enhanced level of detail required from the mine planning stage from qualitative risk assessment (screening level RA) of time-specific risks, to quantitative risk assessment (detailed RA) of latent and residual site risks, post-closure.

As noted by Maczkowiack & Smith (2012), while many environmental considerations refer to the operational phase of the mine's life, the ultimate questions of sustainability relate to the environmental legacy of the mining activities. Hence, by understanding a site's current and long-term rehabilitation-related risks, questions such as 'Can the land be used for its prior use after the mine has closed?', and 'If not, what alternative uses are appropriate?' can be defined upfront in the mine planning process, with suitable rehabilitation measures put in place.

2.5.4 Extending influence of geographic footprints (regional planning)

Possibly one of the most exciting opportunities of upfront land use planning in disturbed areas is the ability to reinstate significantly large functional areas when considering the planning from a regional perspective. Although mines operate within the confines of the licenses, permits and authorisations related to their mining rights' areas, many large mining houses cover expansive footprint areas, and/or comprise numerous operations that occur within one area/region. These are often interspersed/interlinked with similar other operations that face similar challenges, impacts and residual risks.

The above 'regional linkages' provide an opportunity for dedicated next land use and mine closure planning over much larger scales, enabling possible mitigation of cumulative environmental and social impacts in a focused, co-ordinated manner. Furthermore, it provides an opportunity for integrated management/conservation of 'sensitive' social, ecological and economic communities from an overarching perspective which could result not only in mitigation of ecological habitat fragmentation/corridor creation, but also reinstatement of larger expanses of functional agricultural/farming land and the possible development of human settlement/enhancement towards creating identified post-mining sustainable livelihoods.

Bloodworth *et al* (2009) highlight that the minerals industry is unique in being able to provide suitable habitat mosaics and reverse habitat fragmentation through restoration. Good-quality restored areas create secure sites for biodiversity to develop and can provide other important ecosystem services such as flood management, carbon sequestration and food pollination. Poor quality restoration to large 'pit lakes' may give rise to evaporative loss of groundwater (Younger *et al*, 2002) and can raise concerns over bird strike risk to aircraft by attracting large numbers of large water fowl (Civil Aviation Authority, 2006). However, if active mining site management and rehabilitation can be coordinated on a landscape scale, the vulnerability of isolated habitats and species populations can be reduced and additional ecosystem services provided.

In a study undertaken by De Groot (2005), sustainable, multi-functional use of natural and semi-natural landscapes often exceeds the gains from their conversion to single purpose land uses. Natural landscapes commonly provide a multitude of functions and are subject to many possible land uses. Also, for any particular land use, certain areas are better suited for some uses than others and different land uses should be matched to yield the greatest benefits at the lowest cost. Hence, it makes sense than mine closure planning should attempt to create a suite/multiple land uses over the rehabilitated landscape so that a level of sustainability more closely approximating that of the pre-mining landscape can be achieved. This does not imply recreating exact pre-mining land uses, but rather harnessing the altered landscapes' new characteristics to optimise services to communities that either provides similar resourcing needs from the land, or alternative resources that contribute to the long-term economic viability of the area.

However, due to operational complexities, resource competition or, simply, human and financial capital restraints, in most cases a mine's rehabilitation plan will focus within an individual operation's boundaries. Furthermore, Krause and Snyman (2014) note that for communities experiencing the impacts of several mines, it is highly difficult to attribute responsibility for the harms and establish the respective rehabilitation obligations of mining companies. To complicate the matter further, the environmental degradation in communities will also often be, in part, attributable to factors outside of the mining sector including local municipalities and commercial agriculture (Krause and Snyman, 2014).

Also, unfortunately, many land use assessment approaches at the regional scale over the last 15 years are based on highly complex models that require a high degree of parameterisation for which data are lacking (Larondelle and Haase, 2012). Mine closure planning undertaken by the mining company Vale in Brazil further highlight the 'wicked problem' of land use planning in that the larger the planning project, the more local municipalities and stakeholders requiring interaction with, and the greater the dependence, complexity and risks associated with the planning and eventual closure (Picarelli *et al*, 2014).

However, even within the complexities of cross- and multidisciplinary planning environments, this holistic approach to mining-related rehabilitation planning provides several benefits. A clear, early strategy for eventual rehabilitation could reduce the need for mineral or waste re-work, and progressive, proactive treatment of impacts can reduce overall costs. Of course, a mine site can operate for many years, so it is vital that any consultations, agreements, commitments, and arrangements are progressively recorded, and that there is ready access to this information during the rehabilitation phase.

2.5.5 Improving financial viability of operations

Limpitlaw and Briel (2012) identified that the costs of returning land to the low (economic) value pre-mining land use may be far greater than establishing an alternative viable post-mining land use. This viable alternative land use may potentially add value to the community and pressure off-sites for greenfield development elsewhere. However, the counter-argument also stands - the rehabilitated landscapes should offer the same or higher value to remaining communities post-mining, whether this be in monetary value or socially-acceptable ecosystem goods and services. The 2012 BFAP assessment highlights this concern, identifying that the impact of mining on Mpumalanga's economic contribution to South Africa would not only result in a significant reduction in maize production per year, but would also notably increase the average annual maize price This would have significant impacts on the many people reliant on maize meal as a staple food source.

Mining methods, minerals processing and management technologies have developed to a high level of sophistication and efficiency. However, it is often possible to reduce environmental impacts through the implementation of relatively simple and low cost scientific and engineering technologies during the initial stages of project construction as well as operations. Conversely, the cost of retroactive installation of environmental control technologies at later stages in the project life cycle is likely to be prohibitive (Morrey, 1999).

The same principle holds true in terms of next land uses, as the financial cost of 'back-engineering' to facilitate or enable certain land uses late in the life cycle of a mine are likely to be exorbitant in most cases. Failure to adequately consider next land uses during initial planning may therefore hold serious financial repercussions for mines, more so in instances where negative press coverage and public dissatisfaction resulting from undesirable long-term conditions arise.

The BFAP 2015 report highlights that more attention is needed on the creation of a set of sufficient criteria to achieve better success with rehabilitation in future. However, this will contribute to a significantly higher rehabilitation cost initially, since more expertise and inputs are required pre- and often post-rehabilitation. Table 7 highlights some of the key rehabilitation activities required to reinstate the different land capability classes with an expected agricultural potential. Although these activities contribute significantly to the initial rehabilitation cost, they will be offset against the enormous reduction in liability cost a few years later due to a more sustainably reclaimed environment.

Table 7: Rehabilitation activities that contribute to higher rehabilitation costs of difference land capability classes (BFAP, 2015)

		Land Capability Class			
		Arable	Grazing	Wilderness	Wetland
Rehabilitation Activity	Judicious soil stripping	X	X	X	X
	Landscaping	X	X	X	X
	Deeper soil requirement	X	X		X
	Adapted to Shallower soils			X	
	Specific soil types	X			X
	Successional Tillage practices	X	X		
	Amelioration	X	X		
	Pre-revegetation fertilization	X	X		
	Post-revegetation fertilization	X	X		
	Native seed bank		X	X	X
	Biodiversity requirements			X	X
	Post rehabilitation maintenance	X	X	X	

Cummings (2014) highlight some key aspects that could assist mining houses develop a focused strategy for enhancing operational spend towards optimising use of the rehabilitated landscape. These include developing new corporate social responsibility partnerships for managing high-quality conservation assets within mining boundaries; investing in promotion and sharing of rehabilitation research and development; developing an industry-wide account of land under development, repair and relinquishment; supporting development of a national hub for innovation transfer and uptake; and, most importantly, engaging with regulators on how suitably rehabilitated land can be relinquished for active re-use.

It is noted that in most countries, including South Africa, rehabilitation-related financial provision, bonds, trusts, etc., are only released by the regulator on sign-off of successful rehabilitation. As site relinquishment criteria are generally lacking globally, and as regulators become more risk adverse to taking on potential latent and residual risks associated with rehabilitated mined land, mines are currently not convinced that they will ever receive their money put away for rehabilitation. Cummings (2014) correctly notes that much of the above work required to enhance rehabilitation spend could be possibly achieved with more efficient use of the capital tied up in the financial provisions, bonds, trusts, etc. A portion of the capital could be released for investment in partnerships between industry, academia and NGOs, or other formal collaborations. With a singular focus on innovation and capacity building, rehabilitation costs could decline in the medium-term. If these costs decline in the medium-term, original liabilities can still be covered, and landscape restoration initiatives across industries (and across the landscape) can be enhanced – ultimately improving the state of the post-mining landscape.

2.5.6 Creating functional landscape topographies and land capabilities

The most obvious form of landscape transformation associated with mining is an alteration in the topography of the mined area. As a consequence of the huge scale of earth removal and to a natural state is to landscape the topography so that it matches or at least approximates that of the surrounding areas (Carrick and Krűger, 2007). However, this aim is often negated due to poor operational materials movement planning that is driven by economic and logistical considerations and does not adequately consider final location or placement requirements of the material. The result in such instances is that final landforms can be harsh and unnatural in appearance and may also result in long-term surface water runoff or ponding problems. This is especially true for old mines with a long operational legacy, where production drove mining methods and planning for a functional post-mining landscape was not a planning component.

Tailings dams and waste material dumps are often the most visual long-term legacy of mines, and their location, footprint and profile are key aspects that needs to be taken into consideration at the planning stage of a new mine. Although primarily driven by ecological, spatial, operational and cost implications, it is crucial that their final integration into the surrounding landscape be considered from the onset of mining, as failure to do so may impact on potential next uses of areas surrounding the dumps, as well as of the dumps themselves. Dumps with less steep side slopes and concave-convex profile resembling natural landforms could facilitate a greater number of next uses and relate better with the surrounding landscape (Hattingh & Bothma, 2013). However, such landforms may depend on the availability of larger footprint areas and ultimately require better mine planning so that material is correctly positioned from the start of the mining activity (Hancock *et al*, 2003).

Removal, storage and re-application of topsoil and growth medium is another operational aspect that requires a coordinated approach, as failure to do so may eliminate or greatly reduce many post-mining land uses (Limpitlaw *et al*, 2005). Current soil stripping techniques result in mixing of various soil layers, (and hence mixing and loss of their natural functionalities), compaction, and removal or death of the natural seedbank. This results in notable reduction in the likelihood of crop or vegetation re-establishment on rehabilitated areas (*pers. comm*. Dr Wayne Truter, 2016). Soil is also often moved and placed when wet, thereby compacting more readily and creating unfavourable conditions for plant root establishment. Traversing recently rehabilitated areas with heavy machinery, which often happens when operational and rehabilitation scheduling are not adequately aligned, further exacerbates these problems. Furthermore, although opportunities exist for use of alternative sources of growth medium (waste rock, discard, sub-soils, etc.), suitable characterisation of this material is often not undertaken or fully understood towards determining more appropriate and/or alternative options for rehabilitation.

When the above is coupled with a topsoil and/or growth medium deficit to begin with, it becomes that evident that failure to adequately address landform designs and soil management throughout operations may seriously limited the next land use potential of the mined area. Hence, material movement optimisation and placement, and soil management prioritization should be linked to the ongoing mine planning.

2.5.7 Enhancing ecosystem goods and services

Land use becomes a crucial indicator for regional ecological and economic changes. It has also been as one of the important determinant factors of land vulnerability (Zhang *et al*, 2010). Land use change is also the leading driver of biodiversity loss in terrestrial ecosystems and is expected to remain so in the future (Millenium Ecosystem Assessment, 2005).

A rehabilitated landscape will likely provide an altered or lower valued ecosystem for good and services (EGS) in comparison to the pre-mining environment. Removal of large plains of natural grasslands results in reduced flood control, changes to surface and groundwater flow regimes and hence changes to qualities and quantities of water available for downstream users, increased salinity and/or increased soil erosion.

However, research and scientific understanding of EGSs is relatively new, and quantification and valuation of services remains uncertain (Baral *et al*, 2014). Baral *et al* (2014) further highlight that due to the additional uncertainties with the future provision of services due to continuing land use- and climate change, a gross estimate of EGS at a point in time without considering future land use scenarios will have limited value for decision-makers.

In addition, at a regional scale, the value of ecosystems and their functions are rarely considered during the planning process, because the monetary and non-monetary values of ES are still poorly understood (Larondelle & Haase, 2012).

However, by reinstating functional ecosystems, such as wetlands and wilderness habitats, a number of obvious functions are served such as providing feeding, breeding and nesting areas for fauna and creating potential conservation areas for threatened species. The concept of 'environmental economics' is fast gaining ground as the highly valuable range of goods and services that functional ecosystems deliver is being increasingly acknowledged. Other inherent functions of such areas such as flood attenuation, carbon sequestration, water filtration and purification have a measurable monetary value and the need to protect and where possible reinstate these functions is being increasingly acknowledged, and should form an integral part of post-closure land use planning (Hattingh & Bothma, 2013).

In addition, in many countries, legislation now also requires some form of restoration of biodiversity and ecosystem services and/or a form of offset investment. All of this will require increases in financial allocations toward restoration science, technology and implementation, and much more detailed valuation techniques of a rehabilitated landscapes' contributing EGSs (Blignaut *et al*, 2014).

2.5.8 Designing for the needs of the people

During the 1990s, the importance of understanding and mitigating the effects of environmental impacts of mining started coming to the forefront of mine planning. Prior to this, mining focus was predominantly on production, with little consideration for the need to reinstate a functional post-mining landscape (Hattingh, 2017).

As we move into the 21st century, increasing pressure is being placed on companies to provide, prior to receipt of mining rights, detailed plans on how they will contribute towards leaving behind a positive post-mining legacy for the surrounding communities, and/or host governments.

The current increasing trend in resource nationalism seen across the world could prove to be a driving consideration when formulating appropriate rehabilitation and closure objectives for mining operations. The level of closure planning is often underpinned by the sophistication of the mining house, with many international players looking to guidelines and standards such as the IFC, ICMM and local regulations to set the baseline for closure requirements. However, to date, closure planning has focused predominantly on the physical and biophysical environmental components of the closure, with socio-economic aspects briefly touched on in required Social and Labour Plans (SLPs) or associated documents. Community expectations of beneficial post-mining end uses are often high, and may need to be tempered by discussion and examination of the economic and environmental consequences of various closure options.

With current political attention on the need to improve the overall socio-economic conditions in the countries, closure planning focus will need to change substantially towards ensuring planning incorporates key elements for creation of a beneficial, post-mining positive closure legacy (Hattingh, 2017).

Hence, it is essential that planning for mine closure involves dialogue with all relevant stakeholder groups, including government agencies and mining communities – a process aimed at securing a 'social license to mine' (Evans, 2009).

Many companies now see their relationships with the public as being at least as important as regulatory compliance (UNEP & WHO, 1998). Public acquiescence of mining as a future activity is strongly influenced by its vision of ecological performance at today's sites. The rehabilitation of sites which leaves a public asset in terms of farmland, recreation reserves or nature habitat has become an increasingly common policy of mining companies. Such rehabilitation must pay regard to these demands of objectives, going beyond the mere physical stabilisation of slopes and pits and providing a vegetation cover at the least cost.

The South African National Development Plan 2030 (NDP) highlights intentions to diversify the national economy. It was identified that agricultural activities should be expanded to relieve the high levels of poverty in rural areas, and that sustainable agriculture should be the main focus. With the prevailing trends of surface coal mines expanding on available arable land, the realization of this goal might not be possible (Botha, 2014).

The way rehabilitated sites or facilities are used or managed can greatly impact on the success of integration of the site or facility within a functional landscape. For example, remaining mineral reserves are often illegally re-accessed by artisanal miners after a mine has closed which may lead to dangerous or even fatal conditions. Rehabilitated mine areas are also sometimes inappropriately utilised by farmers, who heavily overgraze the land and then blamed the mine in an attempt to access government compensation (Limpitlaw *et al*, 2005). This type of misuse is commonly associated with rehabilitated land that is leased out, illustrating a typical case of the 'tragedy of the commons'.

The re-cultivation of mining sites has been and is still used extensively as a means of re-establishing livelihoods after mine closure throughout the world (Schulz and Wiegleb, 2000), in part since many mines are located in agricultural areas to begin with. However, it is becoming increasingly evident that the pre-mining land capability can seldom be fully reinstated and therefore leads to reduced production levels and decreased livelihood support. The BFAP 2015 report states the following ways that mining can catalyse the establishment and development of commercial agriculture and the agricultural value chain on post-mining land, or in areas adjacent to active mining areas:

- "Leveraging mining infrastructure for lowering the barriers to entry and operating costs for farming in areas where there is mining activity (transport, bulk infrastructure, social, commercial, industrial and administrative infrastructure);

- Use of mining surface rights for farming (mining companies typically have large areas of land holdings that are secured for health, safety and regulatory reasons);
- The economic multipliers of mining serve to spawn secondary and tertiary sectors that support commercial agriculture;
- The use of pumped mine water for agricultural purposes (cheap, treated water);
- Mined intermediate inputs for agriculture (phosphates, lime, trace elements, etc.);
- The ready access to domestic supplies of intermediate inputs for primary agricultural and ingredients and packaging for the beneficiation of agricultural products; and
- The provision of grid-based energy from coal mining".

It is important to note that post-mining land uses do not need to relate to pre-mining land uses, or even to the activities on-site prior to the project. Instead, the new regional reality should be used within the planning domain. Picarelli *et al* (2014) note that although dense population of areas around mining areas, which may be seen as a problem during the operational phase, may present opportunities by the time of closing. Land near urban centers or with logistical opportunities may become more valuable for future use, allowing for the replacement of mineral activity for other land uses that can support and maintain local municipalities.

Furthermore, in general, it appears that areas with greater wealth and more diversified economies can absorb the shock of mine closure more effectively than poorer areas and/or those with less diversified economies (Andrews-Speed *et al*, 2005).

Hence, it is becoming necessary to explore alternate ways of sustaining the affected communities in post-mining regions, more so in the face of increased pressure to ensure long-term food security globally. This has led to the exploration of creative ways of producing the same amount of food from less land, or less productive land than what was available before the onset of mining. Undoubtedly, with current political attention on the need to improve the overall socio-economic conditions in host countries, rehabilitation planning will need to focus more emphatically on ensuring incorporation of key elements for creation of a beneficial, post-mining positive legacy.

2.5.9 Adapting to changing times, changing needs

Changing climate patterns are greatly influencing the way in which mine rehabilitation and closure planning is being undertaken. Although it has increased the uncertainty of effectiveness of some rehabilitation measures, it can also offer opportunities for alternative land use/s.

In China, changing climate in the Yanchang County has resulted in unique advantages for apple and pear growth (Zheng *et al*, 2014). Over the past decade, driven by changing climate patterns and its potential impact on food security for the increasing population, the Chinese government has encouraged development and growth of the county's fruit industry. This has resulted not only in a stable agriculture-based income for local farmers, but has also enabled farming away from sloped areas which were historically the only viable areas for agriculture in the county. It has also improved forest and grassland preservation (Zheng, *et al*, 2014).

Bloodworth *et al* (2009) highlights that some potential novel techniques for recovering energy from coal, such as coal bed methane and underground coal gasification (UGC), are under development and may present a major new energy resource (Younger, 2008; Jones *et al*, 2004). However, there are concerns regarding the possible surface and subsurface environmental impacts of UGC (Holloway *et al*, 2005). These factors, together with the problems of obtaining permission for underground gas storage, (Mineral Planning, 2008b) suggest that public acceptance of onshore UGC may be difficult to obtain

In Buenos Aires, Argentina, cultivation of pejerrey within the Paso de Piedra mine pit lake in the form of established aquaculture activities within flooded open pits, has proven feasible (Mallo *et al*, 2010).

Technological development alters the usefulness and demand for different natural resources. The extension of basic transport infrastructure such as roads, railways, and airports, can open previously inaccessible resources and lead to their exploitation. Technological developments and their application (such as improvements in methods of converting biomass into energy; use of information-processing technologies in crop and pest management; and the development of new plant and animal strains through research in biotechnology) may lead to major shifts in land use in both developed and developing countries during the coming decades (Brouwer and Chadwick, 1991).

Aligned to the above, the concept of planning for 'safe failure' as opposed to planning for 'fail safe' should become an integral component of mining-related rehabilitation and closure planning. Currently it is difficult to predict (with a high level of certainty) the potential occurrence of an extreme natural, or the impacts of such an on a mining site and its facilities. Hence, mine-related land use, rehabilitation and closure planning should be driven by solutions that are more resilient to a future of unknown natural changes.

2.6 Potential post-mining land uses

Acceptance that mining-related land use planning requires a multi-disciplinary approach enables harnessing of out-the-box opportunities for the rehabilitated landscapes. To date, the sometimes seemingly outlandish proposals have been used to create vibrant landscapes which would otherwise have fallen into or remained in disuse. The book '101 Things to Do with a Hole in the Ground' by Georgina Pearman (2009), published by the Post-Mining Alliance in associates with the Eden Project, provides international successful, practical examples of re-created post-mining land uses that have often been generated from out-the-box concepts but, with good planning, have proven to be highly successful.

The literature sources provided below show examples, in addition to those provided in the above book, that have been published on novel post-mining land uses.

It is noted that although some of these publications refer to mining sites where the post-mining land use has already been implemented, it was difficult to verify whether the case-studies have been successful or not. There appears to be a lack of follow-up literature pertaining to, especially, the older case-studies. However, this section still shows that mines have been looking for novel ways in which to manage their long-term liabilities for over 20 years already. In addition, there is a clear movement over time towards practices that provide either renewable energy and/or food-related uses.

2.6.1 Literature supporting planned / implemented post-mining land uses

Aeropower

- Choi, Y. & Song, J. 2016. Sustainable development of abandoned mine areas using renewable energy systems: a case study of the photovoltaic potential assessment at the tailings dam of abandoned Sangdong Mine, Korea. Sustainability, Volume 8, technical note.
- Song, J. & Choi, Y. 2016. Analysis of the potential for use of floating photovoltaic systems on mine pit lakes: case study at the Ssangyong Open-Pit Limestone Mine in Korea. Energies, volume 9.

Agriculture

- Maczkowiack, R.I., Smith, C.S., Slaughter, G.J., Mulligan, D.R. & Cameron, D.C. 2012. Grazing as a post-mining land use: a conceptual model of the risk factors. Agricultural systems, volume 109, pages 76 – 89.

Aquaculture

- Botha, I. 2014. Aquaponics as a productive rehabilitation alternative in the Mpumalanga Highveld Coalfields. MSc Dissertation. University of The Orange Free State.
- Miller, D. 2008. Using aquaculture as a post-mining land use in West Virginia. Mine Water Environ, volume 27, pages122-126.
- AngloGold Ashanti Homase Gold Mine Aquaculture project. 2007. Accessed from http://www.thefishsite.com/fishnews/4329/anglogold-ashanti-commissions-aquaculture-project/ 2017/01/10.
- D'Souze, G., Miller, D., Semmens, K. & Smith, D. 2003. Mine water aquaculture as an economic development strategy: linking coal mining, fish farming, water conservation and recreation. Paper presented at the 2003 Aquaculture America conference, Louisville, KY, February 18-21.
- Otchere, F.A., Veiga, M.M., Hinton, J.J. & Hamaguchi, R. 2002. Mining and aquaculture: a sustainable venture. Proceedings of the 26th Annual British Columbia Mine Reclamation Symposium in Dawson Creek, BC.
- Otchere, F.A., Veiga, M.M., Hinton, J.J., Farias, R.A. & Hamaguchi, R. 2004. Transforming open mining pits into fish farms: moving towards sustainability. Natural Resources Forum, volume 28, pages 216-223.
- Simmons, J., Summerfelt, S.T. & Lawrance, M.I. 2001. Mine water aquaculture – a West Virginia (USA) success story. The Advocate, June 2001.

- McNaughton, K., Lee, P.F., Lindsay, D. & Sudbury, P.M. 1999. The limnology of an open pit fish farm. 1999 international Mine Water Association, Sevilla, Spain.

Biodiesel

- Harmony Gold biofuel to energy, and carbon sequestration, Accessed from http://promethium.co.za/harmony-golds-novel-approach-mining-land-rehabilitation/ 2016/11/09.
- Harris, T., Zaimes, G., Khanna, V. & Landis, E. 2015. Sunflower cultivation on coal mine refuse piles in Appalachia for diesel biofuel production from a life-cycle perspective. Procedia Engineering, volume 118, pages 869-878.
- Marvey, B.B. 2009. Oil crops in biofuel applications: South Africa gearing up for a bio-based economy. The Journal for Transdisciplinary Research in Southern Africa, Volume 5(2), pages153-161.

Solar photovoltaic cells

- Choi, Y. & Song, J. 2016. Sustainable development of abandoned mine areas using renewable energy systems: a case study of the photovoltaic potential assessment at the tailings dam of abandoned Sangdong Mine, Korea. Sustainability, Volume 8, technical note.
- Song, J. & Choi, Y. 2016. Analysis of the potential for use of floating photovoltaic systems on mine pit lakes: case study at the Ssangyong Open-Pit Limestone Mine in Korea. Energies, volume 9.
- Green remediation and utility-scale solar development, Sacramento County, California Accessed from www.epa.gov/region09 2010/01/10.

Tourism / education

- Britannia Museum, British Colombia, Canada. Accessed from http://www.britanniaminemuseum.ca/ 2017/01/10.
- The Eden Project, Cornwall, UK. Accessed from http://www.edenproject.com 2017/10/01.
- Bellavue Underground Coal Mine, Alberta, Canada. Accessed from http://www.bellevuemine.com/about-us/ 2017/01/10.
- Wieleczka & Bochnia Royal Salt Mines, Poland – tours, chapels, workshops. Accessed from http://whc.unesco.org/en/list/32/ 2017/01/10.

2.7 Conclusion

2.7.1 Mining land use planning context

A global awareness of the anthropogenic pressures on the earth has resulted in the incorporation of sustainable development principles into international legislation, global governance structures and individual companies' operating procedures. Mining, with its significant environmental and social impacts, appears to have embraced this concept in its rehabilitation, land use and closure planning.

The considerable biological and physical impacts on water, air, habitats and landscape arising from mining and the waste it produces appear to be well understood. Current ecological rehabilitation focus is on protecting and improving ecosystem good and services of rehabilitated landscapes, thereby creating and improving ecological functionality.

More recently, and as driven by global community needs and demands, the focus of mining rehabilitation and closure planning is turning to social (community) enhancement and empowerment opportunities. This is strongly interlinked with the need to create alternative, renewable land uses that can sustain mining-impacted and surrounding communities, whilst providing sustainable livelihood opportunities. Furthermore, as noted by Limpitlaw & Briel (2014), although the use of mining landscapes can improve the contribution of mining to sustainable land use development, stakeholder participation in establishing post-mining land cover and land use options becomes the critical determining factor for long-term success. This appears to be lacking, in global mine planning.

In developing nations, it appears that governments address mining-related environmental problems within mining and environmental acts, or related national laws (e.g. water- and land laws), where the requirements for mine land rehabilitation are piecemeal and general. In comparison, developed countries tend to have more wide-ranging, stringent and effective regulations in place (Cao, 2007). Concurrently, many developing countries place heavy reliance on traditionally direct controls of environmental policy, and fail to provide incentives such as performance bonding, trusts or financial sureties for mining companies to conduct environmentally acceptable operations. Conversely, developed countries, like the US, Canada, Germany and Australia, tend to combine both command and control approach and economic incentives to stimulate best practice in the mining sector (Kahn *et al*, 2001).

A plethora of both international and country-specific guidelines have been produced, often providing detailed step-wise approaches to the key aspects needing to be included as part of mine rehabilitation and closure planning. Historically and, for the most part, currently, these guidelines specifically require that land be returned to a condition as close as possible to the pre-mining situation. In countries where rehabilitation and closure planning is more progressive, it is typically required that rehabilitation of mined land is to a condition that will minimise negative social and environmental consequence, towards sustaining *an agreed* end use (Maczkowiack & Smith, 2012). To justify the transfer and subsequent appropriate use of the land, mine operators must first quantitatively demonstrate that agreed biophysical criteria have been met and that they can be sustained without the need for exceedingly expensive or protracted maintenance of rehabilitation into the future. As such, guidelines for land rehabilitation commonly recognise hierarchies of acceptability and requirements for rehabilitation by defining a minimum acceptable condition (Doley *et al*, 2012).

South Africa has tried to incorporate global trends along with its main goal of transformation and rectification of historical injustices (Brumfitt, 2013). However, in our country, as with other developing countries, the nature, depth and strength of much of the available legislation and the ability to monitor and enforce associated obligations vary notably between countries, and even regions within a country. In addition, as regulatory authorities are still reluctant to grant closure certificates, mining companies are selecting post-mining land uses that offer the greatest likelihood of relinquishment, rather than the most sustainable land use.

Figure 11 summarises the above mining-related rehabilitation, land use and closure planning global perspective, as gauged during this literature review.

In addition, as emphasized by Han and Zhang (2014), the relationship between land planning-related policy and land engineering (such as mining rehabilitation) can only be achieved via an interdisciplinary approach including a multitude of technical, planning and social stakeholders. Application of integrated land rehabilitation methods to solve regional land use problems, and land rehabilitation disciplines need to be established to take full advantage of land resources and to resolve the land use issues linked to socio-economic development.

Therefore, as highlighted in a recent review of mine closure-related legislation by the ICMM (2015), the following is noted with respect to international mine-related rehabilitation, land use and closure planning:

- Mine closure planning is moving higher up on regulators' agenda;
- International standards, like the IFC Performance Standards and Equator Principles, are playing an important role in developing countries;
- Regulations continue to focus on environmental clean-up and rehabilitation, with increasingly stringent financial provisioning and relinquishment criteria;
- There remains a lack of regulatory structure around socio-economic aspects of mine closure; and
- There are several emerging issues affecting direction of regulations, including climate change impacts and water security.

Ultimately, it appears that defining viable post-mining land uses as a core component of setting rehabilitation goals has come to the forefront of countries in which large portions of the mining industries are reaching the end of their life-cycles. This appears to be driven by the scientific understanding that being able to prove achievement of successful rehabilitation is dependent on a well thought-through post-mining land use/s.

Figure 11: Summary of global mining-related land use planning focus areas

2.7.2 Existing land use planning approaches

Figure 12 illustrates the existing land use planning approaches identified as part of the literature review. These approaches can be divided into three main focus areas – dedicated upfront planning (planning driver), how the land's capability directs land use selection (land capability driver), and land suitability analyses (integrated eco-socio-econ driver).

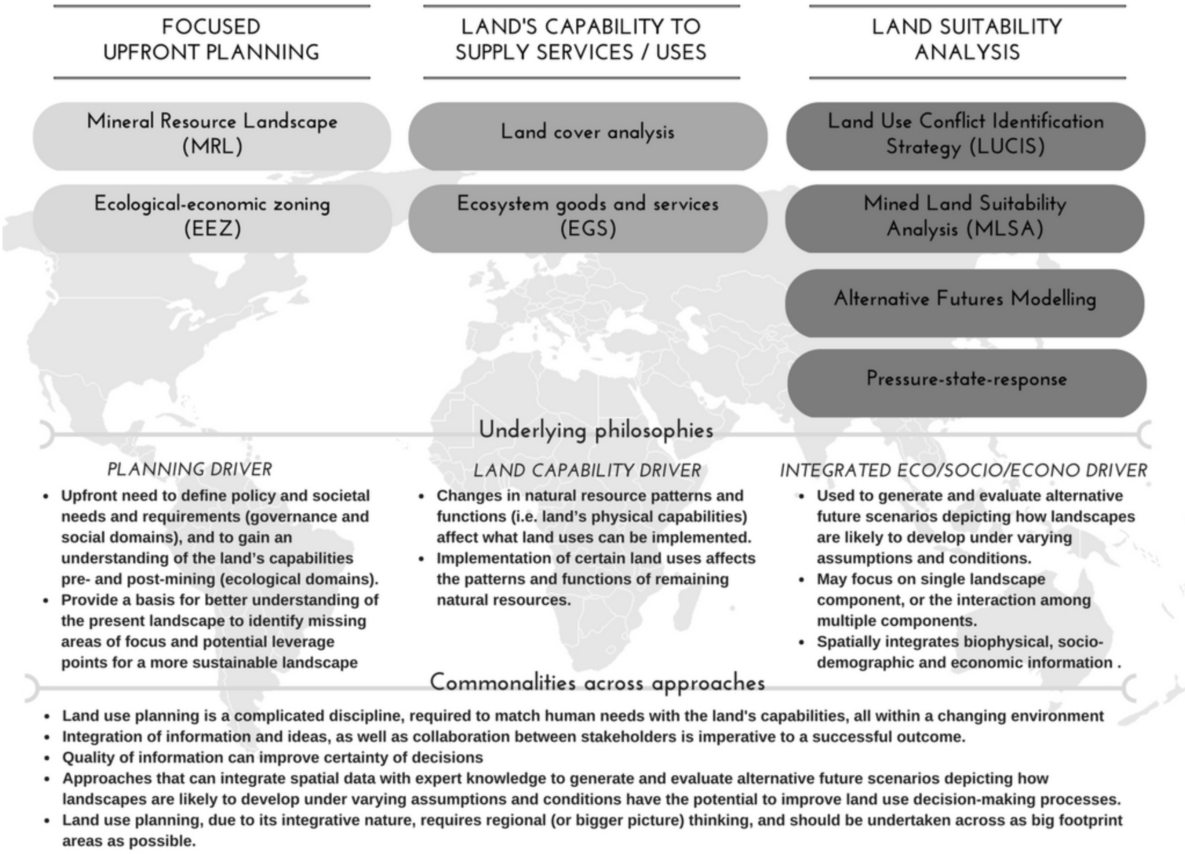

Figure 12: Existing global approaches used as part of land use planning optimisation

Land use planning is a complex discipline, required to match human needs with the land's natural resource capabilities, all within an uncertain changing environment. Based on the information in the sections above, the following key findings of existing land use approaches are highlighted as being relevant to this study. These have also been used to inform key planning components needing consideration as part of the post-mining land use optimisation framework development in Chapter 3 of this study.

- There are a plethora of land use planning approaches, concepts and ideas currently being used globally; some considering specific landscape components, and others using a more integrated landscape-scale approach. Most of these can be applied in some manner to the mining-related rehabilitation and land use planning context.

- Integration of conservation (ecological), agriculture (productive) and urban (human use) land uses is the underlying challenges for land use planning. None of these land uses occur as standalone landscapes and, by the nature of continual land use change, land use planning on the mines should consider the best possible mix of these uses within their planning boundaries.
- Aligned to the above, approaches that can integrate spatial data with expert knowledge to generate and evaluate alternative future scenarios depicting how landscapes are likely to develop under varying assumptions and conditions have the potential to improve land use decision-making processes.
- Integration of information and ideas, as well as inclusion of- and collaboration with a multitude of stakeholders is imperative to a successful planning outcome.
- Site-specific land planning could be short-sighted and incomplete within the larger landscape. Cross-boundary/neighbour land integration could offer more rehabilitation opportunities purely based on increased geographic footprint areas for ecological habitat/productive land/urban development enhancement. There could also be a pooling of human and financial resources to both fund rehabilitation of disturbed areas as well as manage implemented land uses over time.
- GIS is a powerful, illustrative tool that should form the basis for decision-making as well as representation of final outcomes, as part of the land use planning process. However, the quality of the information used to inform these tools will determine the certainty of decisions being made.

2.7.3 Mining-related land use challenges and opportunities

From available literature, the following key aspects could be identified that motivate the need for dedicated land use planning as part of mining-related rehabilitation and closure planning and implementation:

- Readily available and nationally-consistent land use planning is needed to guide preparation for and achieving productive landscapes and prosperous regional communities based on sustainable natural resources use;
- By incorporating land use planning as an integral component of mine planning, the suitability of the mine plant, infrastructure, associated rehabilitated facilities, as well as surrounding land within the mining rights boundary, can be assessed for specific characteristics that could either enhance or impact on the next land use;
- By understanding a site's current and long-term rehabilitation-related risks, questions such as 'Can the land be used for its prior use after the mine has closed?', and 'If not, what alternative uses are appropriate?' can be defined upfront in the mine planning process, with suitable rehabilitation measures put in place;
- A rehabilitated landscape could offer the same or higher value to remaining communities post-mining, whether this be in monetary value or socially-acceptable ecosystem goods and services.

- Inherent functions of rehabilitated areas such as flood attenuation, carbon sequestration, water filtration and purification have a measurable monetary value and the need to protect and where possible reinstate these functions is being increasingly acknowledged, and should form an integral part of post-closure land use planning.
- It is becoming necessary to explore alternate ways of sustaining the affected communities in post-mining regions, more so in the face of increased pressure to ensure long-term food security globally. With current political attention on the need to improve the overall socio-economic conditions in host countries, rehabilitation planning will need to focus more emphatically on ensuring incorporation of key elements for creation of a beneficial, post-mining positive legacy.
- Currently it is difficult to predict (with a high level of certainty) the potential occurrence of an extreme natural, or the impacts of such an on a mining site and its facilities. Hence, mine-related land use, rehabilitation and closure planning should be driven by solutions that are more resilient to a future of unknown natural changes.

The above are summarised in Figure 13.

Figure 13: Key aspects motivating the need for dedicated land use planning as part of mining-related rehabilitation and closure planning, and implementation

2.7.4 Trends in published post-mining land use case-studies

Figure 14 provides a snapshot of identified post-mining land uses, across regions, that could be identified from available literature. In parallel, Figure 15 focuses on the South African landscape and summarises literature-sourced planned, implemented, in-progress and ceased post-mining land use case-studies. Based on these figures, and related literature, the following post-mining land use trends both globally and in South Africa are evident:

- Although there are published examples of planned and implemented post-mining land uses, this literature is often more than 10-years old, and hence could be considered outdated. There is also very limited follow-up information on implemented case-studies. This provides restricted knowledge on suitability for implementation, possible challenges and opportunities faced, as well as how success could be determined.
- Interestingly, most published literature can be clearly zones to certain regions, with the USA, Canada and Europe having the most available case-studies. This links well with the consolidated findings in Figure 11 which indicate that Canada and Germany, specifically, have developed, focused land use research institutes.
- Developed nations such as the USA, Canada and Europe indicate land uses related to renewable energies such as solar- and hydropower. This may be linked to the human need for energy, especially where urban areas are continuing to expand, with limited natural resources. This renewable energy trend is also indicative in the highly populated regions of China.
- The developed nations also show numerous education/tourism land uses in the forms of museums and heritage resources, indicating a focus on using historic mining sites for establishment and continuation of cultural knowledge.
- In Australia, there is a mix of land uses, but they appear to harness the vast spaces and warm climates of the area – in the form of solar panels, agriculture and bioenergy.
- African case-studies appear to focus on food production, in the form of aquaculture and agriculture. This seems relevant, as food security remains a priority in national planning throughout the continent.
- In South Africa, previously implemented post-mining land uses appear to have been retrofitted to the closed mine sites. This could indicate that these land uses were implemented in hindsight, with limited pre-planning. For example, many of these uses relate to recreation/sport (such as fishing) in remaining voids, biodiversity in pre-mining ecological areas and farming in pre-mining farming areas. However, examples of land uses currently being planned indicate a shift towards regional planning needs (of the people) – bioenergy, solar- and hydropower schemes to cater for rising urban energy needs (and rising coal-related energy costs), carbon sequestration to counterbalance greenhouse gas emission targets, and ecosystem goods and services' protection in ecologically sensitive areas.

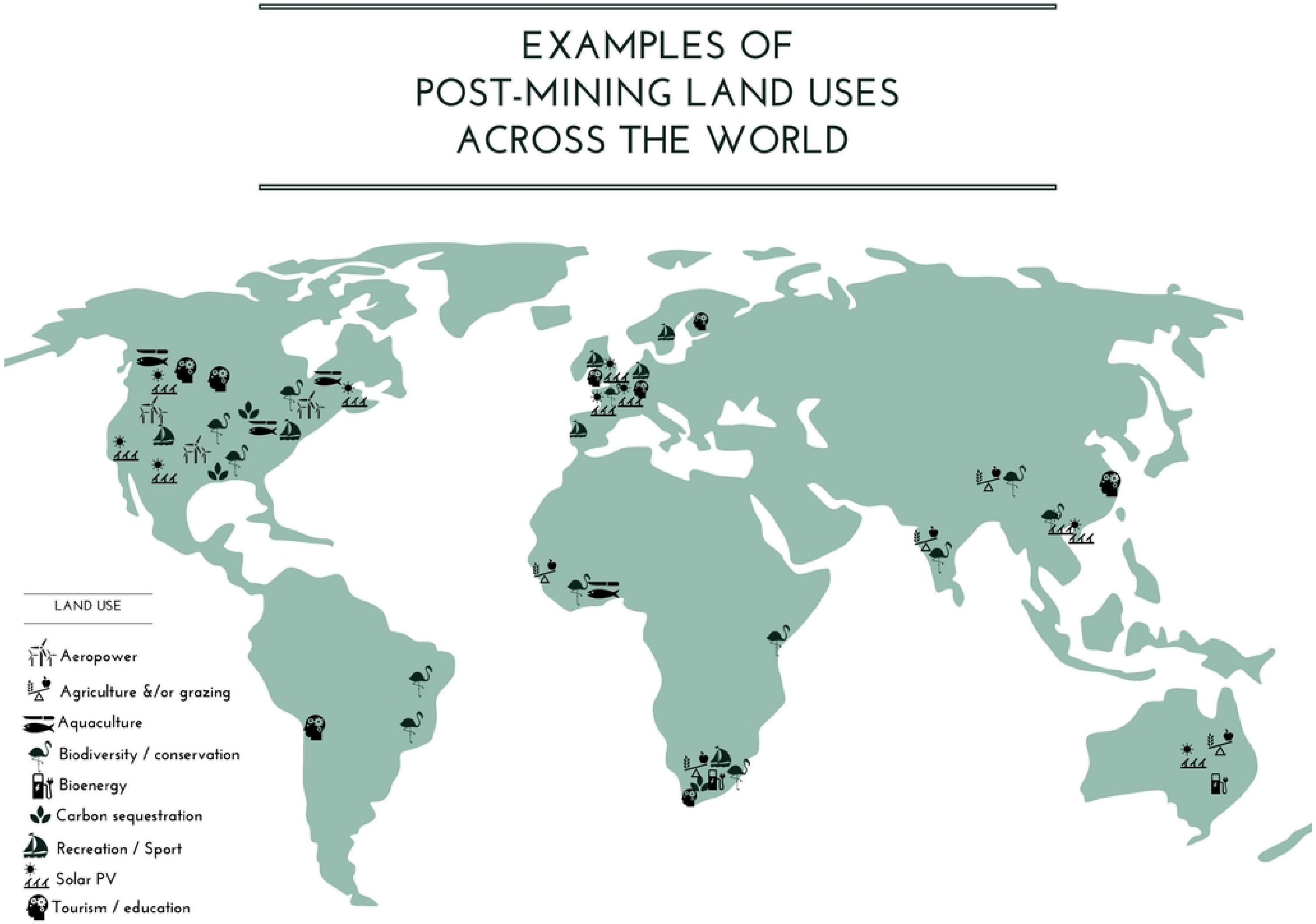

Figure 14: Summary of literature-specific post-mining land uses documented as having been implemented internationally

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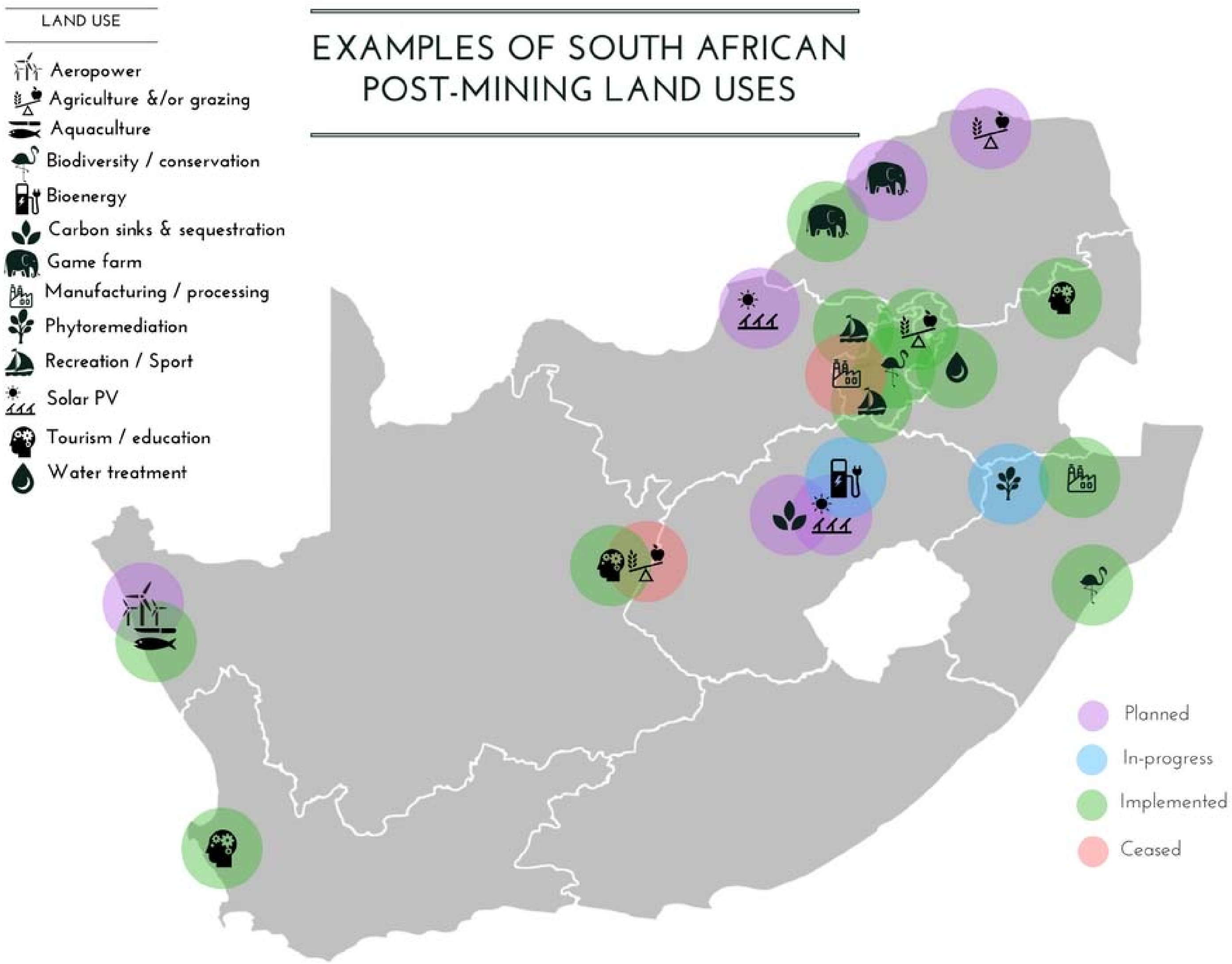

Figure 15: Examples of post-mining land uses in South Africa – planned, implemented, in progress and ceased

2.7.5 Key aspects guiding mining-related land use planning

Key available literature agrees that pre- and post-mining landscapes often differ dramatically from each other, primarily in terms of sub-surface soil (pedological) structure, land capability, resource (soil, vegetation and water) availability as well as human settlement-related infrastructure. Ultimately, surface mining always involves a twofold change in land use, from a pre-mining landscape to a mining landscape, and then from a mining landscape to a post-mining landscape (Figure 16).

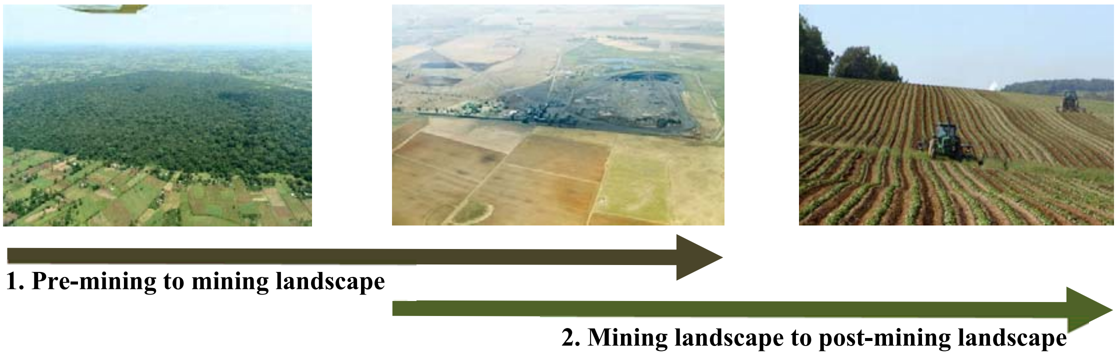

Figure 16: Evolution of surface mining landscapes – pre-mining to mining, and then from mining to post-mining

However, the literature also agrees that as areas affected by mining continue to increase, a more integrated assessment of the mining landscapes is urgently needed to achieve more sustainable post-mining development (Larondelle and Haase, 2012).

Based on the above regulatory context, existing land use planning approaches and identified challenges and opportunities as gauged from available literature, the following aspects have been identified as key components guiding mining-related land use planning:

- Land use planning is highly complex and requires consideration of multiples objectives including environmental, ecological, economic, social and other factors.
- The above objectives need to be further considered within an appropriate spatial and temporal context, taking cognisance of regional planning drivers.
- Regional drivers for post-mining land use planning should be used to devise overarching site rehabilitation goals, towards creating a 'substitution economy' to ensure post-mining community sustainability.
- Land use planning should consider improved use of local natural resources, existing facilities and/or infrastructure, towards optimising rehabilitation of brownfields' disturbances and/or the need for excessive greenfields' development.
- Some parcels of land can be used to accomplish multiple land use goals, and some land uses offer more flexibility in terms of future or adjoining uses than others (cross-boundary uses).

- Pre-mining land use/s would be very technically, practically and financially challenging to recreate due to the significant alternation of the pre-mining landscape by the mining process. Hence, post-mining land use could focus on recreating alternative land use/s that optimise available, post-mining resources.
- Novel, economically-feasible land use options should be explored that could also manage or mitigate long-term environmental and social impacts associated with the rehabilitated site.
- The earlier post-mining land use planning is incorporated as part of mine and associated rehabilitation planning, the greater the opportunity for recreation of a diversity of functional alternative land uses, aligned to stakeholder expectations.
- It is imperative to engage with all affected communities/stakeholders throughout mining operations to facilitate a consultative process that develops and builds consensus on an overall strategy to establish a diversified sustainable post-mining local economy, and to identify projects (agriculture, health, small and medium enterprises, etc.) that can be implemented and become entrenched before mining moves away from the area.
- Post-mining land uses should be underpinned by an appropriate institutional and organisational base, including capacity building of local government structures and/or third parties to takeover infrastructure and related services.
- Land use planning should incorporate development of mine employee and stakeholder training programs aimed at improving the local skills' base, multi-skilling and eventual transfer of skills to other livelihood and economic activities post-mining.

The aforementioned information has provided guidance on key aspects that should be considered as part of mining-related land use planning. These have been used to underpin development of the post-mining land use decision support framework as part of this research, as now defined in Chapter 3.

CHAPTER 3: PRELIMINARY POST-MINING LAND USE OPTIMISATION FRAMEWORK

3.1 Introduction

3.1.1 Background

Land use planning presents a development approach that contributes to the prevention of land use conflicts, the adaptation of land uses to physical and ecological conditions, the long-term protection of land as a natural resource, the long-term productive use of land and a balance that fulfils all social, ecological and economic requirements (BMZ, 2011). The findings from the literature reviewed in Chapter 2 supports this statement. In the context of this study, this therefore implies that dedicated mining-related land use planning has the potential to integrate varying data and planning domains. This integration could assist in being able to identify and manage the most suitable trade-offs between inevitable rehabilitation-related environmental, economic and social site impacts.

A *framework* is defined by the Australian Department of Industry, Tourism and Resources (2006) as 'a logical procedure for coordinating decisions that link developmental goals with the actions intended to achieve those goals'. *A logical procedure for coordinating decisions* could be supported by asking pertinent questions specific to the subject matter. Hence, this post-mining land use optimisation framework is specifically aimed at providing such a logical, step-by-step decision support approach. The approach is presented in the form of relevant questions needing to be considered as part of a structured process flow which has been developed based on the findings of the literature review. Ultimately, this framework aims to assist mines in coordinating the plethora of land use-specific planning-related decisions that need to be made to optimize the way rehabilitation can be incorporated into the site's overall mine planning.

3.1.2 Framework intent

As mentioned above, the preliminary post-mining land use optimisation framework conceptualized in this Chapter of the study aims to provide the questions to be asked to define a site's post-mining land use goal as early on in the mine planning process as possible. It includes thinking around identifying relevant land use planning principles and related rehabilitation objectives, all the while trying to integrate local and regional environmental, social, economic, institutional and political planning needs.

The following components, based on findings from the literature review, are considered critical for inclusion within the structure and function of the framework, towards enhancing mining-related land use planning thinking:

- Land use planning needs to be incorporated as early on as possible within the mine planning. This is required to define a post-mining land use, or suite of uses, against which site rehabilitation measures can be devised. Without a clearly defined next land use, rehabilitation could be uncoordinated, short-sighted and expensive.

- Defining a post-mining land use early on in the mine planning provides an opportunity to consolidate operational rehabilitation-related site needs, challenges and opportunities. Having a common vision that has been devised, and bought-in by all mining team members improves commitment and accountability from all to achieve the goal. It also allows attention to be more focused on a common outcome, with mine planners, implementers, specialists and accounting teams better understanding how their roles can contribute to this outcome.
- The defined post-mining land use goal should take into consideration local, regional and national land planning needs. This can improve integration of the rehabilitated landscape with surrounding land uses, as well as align the rehabilitated land's capabilities with regional environmental, social, economic, institutional and political needs.
- Consideration of regional land use needs implies undertaking rehabilitation within as large a geographical footprint area as possible; not just within site boundaries. It also implies that adjacent sites and, even, larger geographical mining complexes can work together to recreate defragmented landscapes that have a larger ecological, agronomic and/or social positive influence.
- Land use-specific planning is not currently a clear driver within South African mining-related legislation (or, even, within international legislation). Instead, focus is on rehabilitation planning, of which land use is only an aspect that is not yet given adequate attention as part of this rehabilitation planning. Currently, compliance with local regulations with respect to post-mining land use planning implies standard, but not good practice. Hence, from a rehabilitation perspective, it is evident that good (or best) practice should be the norm for incorporating land use planning within mine planning as it is the driving component of recreating a functional post-mining landscape.
- Successful implementation of a defined land use is almost totally reliant on the land capability of the rehabilitated site. Hence, the earlier on in planning a next land use is defined, the sooner site construction, operation and rehabilitation measures can be tailored towards achieving this land use. On the other hand, without a clearly defined next land use, rehabilitation activities such as ongoing soil conditioning, re-vegetation and active land management could become overwhelmingly large human and financial cost items for the mine.
- Successful implementation of the most feasible post-mining land use, or suite of uses, is only possible through consultation with- and incorporation of stakeholder views and knowledge. This remains possibly the most challenging aspect of a mine's planning domain. Defining the land's and people's needs for a post-mining landscape, which is often more than 10 – 20 years into the future, early on in a mine planning process requires foresight into changing localized and regional needs. It also requires

compassion and understanding as stakeholders can often be emotive in their thinking. This aspect does not imply that a mine should focus its land use planning purely on stakeholder views, opinions and needs, but instead encourages ongoing transparent integration of these views into the planning process, throughout the mine's life. Building such relationships will improve stakeholders' understanding of the mine's rehabilitation- and land use challenges. Should changes in the post-mining land uses be required, this understanding could be used to support and assist in identification of viable alternatives.

Aligned to the above, the intent of this framework is aimed at empowering mines to seamlessly integrate their post-mining land use planning within their overarching rehabilitation- and mine plans, towards ultimately creating a functional, post-mining value generating land asset.

3.2 Methodology: framework development

Based on the above, the preliminary post-mining land use optimisation framework has been compiled considering the following five fundamental steps, or planning components:

- Step 1: Defining the post-mining land use planning context;
- Step 2: Defining a desired post-mining land use goal, based on the planning context;
- Step 3: Understanding the mine's current land capabilities, and how these are aligned to the desired post-mining land use goal;
- Step 4: Determining how rehabilitation actions identified and/or already being implemented are aligned to achievement of the desired post-mining land use goal; and
- Step 5: Undertaking measurement and monitoring of rehabilitation, towards achieving the desired post-mining land use goal.

Due to the importance of integrating post-mining land use and associated rehabilitation goals early in the mine planning, the framework comprises a comprehensive upfront planning component - Step 1. This upfront planning results in conceptualization of a post-mining land use goal - Step 2.

Step 3 covers the understanding of the mine's current land capabilities, towards achieving the conceptualized post-mining land use goal. (It is noted that this Step would be significantly different for brownfield and greenfield operations, the details of which is provided in the sections below).

Step 4 involves aligning the site's rehabilitation measures with the land use goal. Again, this would be notably different for brownfield and greenfield operations. However, the aim would be to implement the required rehabilitation measures, aligned to the post-mining land use goal, as soon as possible (Step 4.1). This would avoid either having to re-rehabilitate areas due to available land capabilities not being able to support the land use needs (Step 4.2), or having to re-define the post-mining land use goal should it be identified that the available land capabilities would never be able to achieve the land use needs (Step

4.3). Both options would require notable financial and human capital, and even possibly re-alignment of land use-related commitments made within environmental authorisations.

Finally, Step 5 considers the measurement and monitoring required towards achieving the post-mining land use goal, via the defined rehabilitation measures.

The rationale behind each of the above steps has been provided in the following sections.

3.3 Results and discussion: preliminary framework

3.3.1 Step 1: Define planning context

Planning for mine rehabilitation represents the difficult task of being able to meet the needs of the present without compromising the needs of the future. Based on the literature reviewed, it is evident that to improve the chance of achieving successful rehabilitation of a mine site - time, effort and dedication in upfront selection of the most suitable suite of rehabilitation measures is required. Rehabilitation therefore requires focused attention on a plethora of planning domains by a multitude of stakeholders and disciplines to meet these needs, both present and future.

At the mine level, the desire for optimised financial performance drives the operational efficiency and its subsequent profitability; the need for regulatory compliance drives risk management through minimisation of long-term environmental impacts, while the focus on sustainable long-term livelihood creation is guided by the mine's social license to operate. But how does one reach an inclusive consensus between all the stakeholders involved that still meets the principles of sustainability?

This framework emphasises that only once time and effort by a dedicated, informed team has been spent on understanding the overarching planning context of the mine site, can a viable post-mining land use goal be identified, and subsequent rehabilitation measures defined. Without this planning context, rehabilitation could be haphazard, uncoordinated and, ultimately, result in the need for costly re-rehabilitation. Accordingly, a significant portion of the framework comprises core upfront planning components, the key planning domains of which are identified below.

3.3.1.1 Step 1.1: Defining a desired rehabilitation intention - doing the right thing (the 'value driver')

The first component of Step 1 assumes the mine's desire to make a value- or ethical-based decision on the functionality of the post-mining landscape. As so aptly put by Comp (2013), 'anyone who works for very long on environmental issues, particularly reclamation of previously mined lands, begins to realise that environmental 'problems' are created and defined not by science but by our culture. We as a society decide what we care – and do not care- about at any given time". Hence, Step 1 supports the notion that as a major contributor to the land's disturbance, a mining company would choose to 'do the right thing' from a rehabilitation perspective. Ultimately, it implies a dedicated land stewardship role is assumed, willingly, by the mine.

Doley *et al* (2012), in Australia, derived four interconnected 'environmental rehabilitation scenarios' which emphasise distinct pathways for rehabilitation (or lack thereof) – 'least impact', 'conventional practice', 'shifting ecological function', 'social and environmental irresponsibility'. Each scenario has distinct long-term objectives and management inputs to identify likely rehabilitation linkages and challenges. These scenarios have been modified in this study to support the mine in defining a *desired post-mining rehabilitation intention* – i.e. this step in the framework assumes that the mine has the luxury of choosing a preferred (or desired) post-mining landscape that it intends to rehabilitate towards. Ultimately, it represents the upfront planning *value driver*, aimed at supporting the mine in 'doing the right thing'.

As also identified by Doley *et al* (2012), a feature of the 'rehabilitation intentions' is that novel ecosystems and agro-ecosystems (referred to in this framework as the 'alternative landscape function') have a 'range of commercial and societal values that could bridge the conceptual divide separating the ecological function of derelict and/or unusable landscapes versus re-instated 'natural' landscapes'. When considering the successes of post-mining rehabilitated landscapes, it is critical to determine which essential landscape features define the pre-existing 'natural' ecosystem, and how many of these landscape features remain within the post-mining landscape and what is their integrity (Doley *et al*, 2012). Based on this understanding, a preliminary assessment of whether these landscape features can be recovered (e.g., aiming to re-instate the 'natural' landscape) or whether an alternative landform should be considered as a more attainable rehabilitation outcome.

The following four 'rehabilitation intentions' have been derived for the framework:

- **Maintain landscape function**:
  - Avoidance of irreparable ecosystem disturbance;
  - Reinstate pre-mining landscape; with same as pre-mining landscape functions; and
  - Protection of pre-mining ecosystem goods and services.
- **Mimic natural systems**:
  - Reinstate 'natural' landscapes, similar to pre-mining functions; and
  - Ecological functionality, with pre-defined (limited) impact on ecosystem goods and services.
- **Alternative landscape function**:
  - Alteration of pre-mining land uses; limited similarity to pre-mining landscape functions; and
  - Supporting pre-mining ecosystem goods and services, but through alternative land uses.
- **Exploit landscape**:
  - Destruction of pre-mining landscape; no viable long-term land use; and

- Total loss of pre-mining environmental / social landscape function;
  (Could be facility-specific (e.g. tailings dams, waste rock dumps)).

Based on the above, it is noted that brownfield mining sites (i.e. those sites already disturbed by mining, or other operations) will have much less flexibility in selection of one of the above rehabilitation intentions. In fact, many existing mining sites are already functioning within the 'exploit landscape' domain. It is assumed that 'maintain landscape function', if not already included as part of the site's rehabilitation planning, will be impossible to achieve. 'Mimic natural systems' will also be a challenge. However, this study does not assume that all the rehabilitation intentions cannot be achieved by brownfields sites; only that significantly more human and financial resources would be required to realize these outcomes. This challenge for mining sites implies that the earlier on in the mine's life-cycle dedicated post-mining land use planning is undertaken (ideally, within the prefeasibility planning stage), the greater the flexibility in selection of achievable rehabilitation measures available to the site.

It is also envisaged that the mine will select only one overarching desired rehabilitation intention. Selection of a suite of rehabilitation intentions will result in varying levels of site functionality which could further complicate conceptualization and implementation of measurable relinquishment criteria. Ultimately, the aim of establishing a *desired rehabilitation intention* is to define the way rehabilitation of the site will take place – maintaining landscape function, mimicking natural systems, providing alternative landscape functions, ***or*** exploiting landscape functions.

3.3.1.2 Step 1.2: Identifying regional land use needs (the 'land planning driver')

Forman (1995) suggests that land use planning begins with determining nature's arrangement of landscape elements and land cover and then considering models of optimal spatial arrangements and existing human uses. Furthermore, Dale *et al*, 2000 suggested that a desired landscape mosaic be planned for according to basic human needs - first for water and biodiversity (ecosystem goods and services); then for cultivation, grazing, and wood products (food security); then for sewage and other wastes; and finally, for homes and industry.

For this framework, understanding the spatial and temporal planning domain which the mine will be / is operating in, and the associated longer-term human needs identified for the rehabilitated landscape is considered a critical land use planning component. Hence, Step 1.2 focuses on the identification and incorporation of 'regional land use drivers'. These drivers are underpinned by a region's basic land and human needs, as gauged from available regulatory planning documents. In South Africa, these regional land use drivers could be aligned to needs identified in at least the country's National Development Plan (NDP, 2013), as well as municipality-specific SDFs and IDPs.

Water conservation and preservation

Land use and water resources are inextricably entwined. The need to protect the quantity and quality of water resources can impact potential land uses and land management practices, while water availability is a pre-requisite for a plethora of land uses such as agriculture, mining and urban settlement. Land use and land management changes impact on water resources for example through changes in catchment yields, infiltration rates, dissolved organic carbon and nutrient transfers surface- and groundwater resources (Weatherhead & Howden, 2009).

Mining is a water-intensive activity that is intrinsically exploitative of water resources and water-based ecosystems, most often altering both the quantity and quality of water flows. During operations, the impacts on groundwater aquifers and surface water resources relate predominantly to water volumes – open pits and underground mines are often dewatered below regional groundwater levels to ensure safe operating conditions. This pumped water is usually incorporated within minerals processing activities during operations, and hence cannot contribute to local catchment integrity during the operational phase. As a site nears decommissioning, focus changes to measures required for long-term water quality management. This typically involves some form of intensive water treatment before it can be re-used and/or releases into local water resources. Both the pumping, temporary storage and re-use, and treatment of water resources affected by mining contribute a substantial portion of the site's rehabilitation costs.

As mining often happens in the headwater regions of river basins, the use and diversion of water by mining companies considerably affects downstream water flows. Studies analysing the impacts of extractive industries in Bolivia, Ecuador and Peru show how mining operations entail both changes in water quality, polluting rivers with mining waste, as well as changes in water quantities, altering and reducing downstream water availabilities (Sosa & Zwarteveen, 2014). In South Africa, the upper Olifants River system in the Mpumalanga Province is of strategic importance for several land and water use activities (mining, agriculture, power generation, etc.), all of which rely heavily on numerous goods and services they derive from local aquatic ecosystems. Associated with the catchment's key water quality parameters are threshold concentrations which, if regularly exceeded, can result in harmful impacts on aquatic ecosystems and human health. Research and field observations indicate that these thresholds are increasingly under threat, and that abandoned mining areas are clearly the most important source of metals in the upper Olifants system (Dabrowski & De Klerk, 2013).

South Africa is also a water scarce country. Moreover, its rainfall varies dramatically from season to season and is distributed unevenly across the country. This, together with the water pollution effects highlighted above, poses several challenges from a regional land use planning perspective. Considering the water-energy-food nexus, Gulati *et al* (2014) highlight that in future, it may require that South Africa make crop choices in the context of water scarcity and its effect on food security; water scarcity will also affect food production indirectly through competing with energy production, which will lead to trade-offs with the energy and resources sectors; and increasing water pollution in South Africa means that food producers will find it difficult to meet regulatory requirements of food safety and quality norms. Weatherhead and Howden (2009) highlight that to conserve water resources into the future, land uses that contribute to protecting water resources and maintaining good soil structure to encourage infiltration rates and water quality, should be prioritized.

The above water-related aspects underpin planning challenges that require consideration if the functionality of the rehabilitated landscape is going to be resilient to future climatic variances. Especially in a water scarce country like South Africa?

<u>Land productivity (food security)</u>

"Coal under the ground is worth more than growing rice on the surface" - Gary Lye, Executive Director of GCM Resources (Melik, 2006). Plans to displace 50,000 to 220,000 people for the GCM Resources Phulbari Coal Mine in Bangladesh, India were premised on the above economic valuation concerning the mineral extraction of coal, or the harvesting of rice for food. The question here is valuable to whom? (Plumridge Bedi, 2014).

Globally, agriculture is facing an increasing demand for food, bio-based energy and fiber products (Gutzler *et al*, 2015). Farmers' adaptation to the increasing demand may include changes in the choice of crops, crop rotations, utilization of crops, and intensification of production. Trends include technical solutions to remove yield-limiting factors, such as water availability for crops, and increasing use of agricultural biomass as a source of renewable energy. This adaptation is taking place underpinned by techniques and solutions that need to consider more irregular precipitation patterns due to climate change. However, it is also noted that agriculture is multifunctional. This means that in addition to (private) economic production, it contributes to public goods such as the character of rural landscapes and its ecosystem services (Gutzler *et al*, 2015).

Food security is "a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (Food and Agricultural Organization, 2003). One of the visions stated in the South African 2030 NDP is to increase and expand agricultural development, such as irrigated agriculture and dry-land activities, to relieve poverty in the rural areas (NDP, 2013).

From a mining perspective, the competition for natural resources is most visible where mining and agriculture compete for high value agricultural land (BFAP, 2015). In South Africa, it is noted that collaborative work is being undertaken by institutes such as the BFAP, to more accurately quantify the impacts of coal-specific mining on the country's agricultural potential. (The 2015 BFAP report highlights that mine-owned land (surface and open-cast mining areas) intersected by agriculture (grains and oilseeds croplands only) amount to 365 806 ha in Mpumalanga (27% of cultivated fields in province)). However, to date, much of the available data has assumed that all land within an allocated mining rights' area is not available for other land uses during the mine's operational life. This is inherently incorrect. Although mines are not in the business of farming within their mineral rights' areas, the presence of 'fallow' land does not necessarily mean 'wasted' land, as it often is perceived from a commercial agriculture point of view (Kepe & Tessaro, 2014). This land may, and should, be used for cropping, grazing or a range of natural resource uses.

In addition, aside from direct land impacts, mining activities could also increasingly affect agricultural production through the reduction in the supply and quality of water resources. This effect is both via direct environmental degradation and generation of mining-related pollution that impacts both nearby existing and potential future agricultural activities.

Hence, the competition between mining and agriculture for scarce natural resources can increasingly affect the economy, food production and resource availability if not managed carefully. The historic unidirectional conversion of productive land from agriculture to mining raises serious concern with respect to the future management of and the options for the sustainable use of natural resources. These natural resources (such as land, water and clean air) are essential for human well-being and to produce food.

Functional ecological systems

"Biodiversity is neither a marketable good or product, nor a service; it is the living web that connects the tangible and intangible elements of healthy ecosystems, which is the essence of so-called renewable natural capital. The maintenance of biodiversity is therefore not just an ecosystem service among many—it is the *sine qua non* of ensuring a sustainable future" (Blignaut & Aronson, 2008).

Since the publication of the Millennium Ecosystem Assessment in 2005 there has been a surge of interest in ecological restoration (ER) to recover biodiversity, re-establish ecosystem functioning and connectivity, and reactivate the delivery of ecosystem services (Blignaut *et al*, 2014). Ecosystem services have become an important concept in policy making, with decision makers having to trade-off competing demands for various benefits from agriculture, tourism and potable water from a broad range of stakeholders (De Groot *et al*, 2010).

It is noted that the ecosystem processes that underpin and contribute to a service often reside under different legal and policy domains and management agencies (Rounsvell *et al*, 2012). For example, land use legislation and policy guide land use (and land cover) change and typically fall under agricultural governance systems, while water quality issues fall within in the domain of water services governance systems, and riverine systems under natural environmental governance systems (Le Maitre *et al*, 2014). The separation of mandates and jurisdictions, as well as their focus on domain-specific expertise, can lead to decisions on different land use options overlooking the cumulative impacts on downstream users.

Dale *et al* (2000) identified the following five principles of ecological science particularly relevant to land use planning, all of which influence the manner in natural systems will respond to human-induced land use changes:

- *Time*: Ecological processes occur within a temporal setting and change over time is fundamental to analysing the effects of land use;
- *Species*: Individual species and networks of interacting species have strong and far-reaching effects on ecological processes;
- *Location*: Each site or region has a unique set of organisms and abiotic conditions influencing and constraining ecological processes;
- *Disturbance*: Disturbances are important and ubiquitous ecological events whose effects may strongly influence population, community and ecosystem dynamics; and
- *Landscape*: The size, shape, and spatial relationships of habitat patches on the landscape affect ecosystem structure and function.

Prioritising landscapes for the production or harvest of a single ecosystem commodity, such as food or fibre, or within only one of the above principles, can diminish other services such as water quality, erosion prevention or soil formation as well as under-mining overall ecosystem resilience (Baral *et al*, 2014).

However, land that is of great value for conservation is often also be highly suitable for human use, resulting in competition between urban development and the protection of natural resources. Dorning *et al* (2015) note that maintaining ecological connectivity within human-modified (and rehabilitated) landscapes could encourage the movement and persistence of species, particularly under the threat of changing climate. Hence, mining-related rehabilitated areas offers an opportunity to improve the quality of landscapes outside of protected areas which can be important to species persistence and at the same time provide important ecosystem functions.

It is foreseen that as legislation is developing and placing more attention on the need for some form of restoration of biodiversity and ecosystem services and/or a form of offset investment, mines will be required to increase financial allocations toward restoration science, technology and implementation, and much more detailed valuation techniques of a rehabilitated landscapes' contributing EGSs (Blignaut *et al*, 2014).

<u>Energy</u>

South Africa produces an average of 224 million tons of marketable coal annually, making it the fifth largest coal producing country in the world. The country exports about 25% of this production and is the third largest coal exporting country globally. Of the domestic consumption, 53% is used for electricity generation by the state-owned utility - Eskom, the 7th largest electricity generator in the world (BFAP, 2015). South Africa has relied on exploiting its coal resources to meet growing electricity demand, predominantly since coal yields cheaper electricity than other production sources. South Africa has therefore developed a heavy reliance on cheap coal-based electricity, with coal accounting for 85% of total installed capacity (Gulanti *et al*, 2009).

However, over the past few years, the capital costs for renewables have continued to drop considerably. Consequently, many renewable solutions are now less expensive than diesel. At the same time, the ability to engineer a hybrid renewable solution that is highly reliable has increased (Judd, 2013). In addition, until recently, the electricity sector in South Africa was dominated by Eskom, which owns the transmission network and half the distribution networks in the country (Promethium Carbon, 2016). The sector has since opened up to new independent Power Producers (IPPs) with a view to creating competition in the market. However, South Africa lacks the necessary transmission and distribution infrastructure to help put electricity back into Eskom's national grid, which may not bode well for alternative industries wanting to put electricity back onto the grid (Kotze, 2014).

With respect to the global political goals set for energy production, pressure on limited land resources will increase in the coming years, not only to provide raw materials for ambitious goals in renewable energy production and to substitute fossil resources, but also to feed an increasing world population. Accordingly, the demand for plant biomass offers new opportunities for agriculture and forestry. New markets can emerge, such as for thermal utilization of forest residues, roadside vegetation and landscape management actions (Wachendorf *et al*, 2008). The bioenergy sector has received considerable governmental support in many countries. However, conflicts between the different objectives of bioenergy development, ecosystem and biodiversity protection as well as landscape issues in particular become more and more obvious (Lupp *et al*, 2014). Despite their possible contribution to a reduction of greenhouse gas emissions, a non-selective and unregulated cultivation of crops cultivated for energy production has negative impacts not only on biodiversity, but can also lead to soil erosion, nutrient spill-overs and negative impacts on landscape aesthetics (Lupp *et al*, 2014). On the other hand, a connection between the production of bioenergy and irrigation exists - as farmers become fuel suppliers for power plants, it becomes more important to achieve stable yields even in dry years (Gutzler *et al*, 2015).

In South Africa, the Department of Energy (DOE) Integrated Resource Plan 2010-2030 (IRP, updated 2013) places emphasis on moving towards a greener economy in the long run. The 2013 revision provides for less coal, hydropower and wind, but more gas, solar photovoltaic (PV) and concentrated solar power (CSP) capacity.

Some mining companies have started using innovative approaches that simultaneously combine renewable energy with biogas and land rehabilitation. Mining companies can consider several post-mining land uses, such as the creation of carbon sinks and transforming rehabilitated mine land into energy crop plantations for a renewable biogas production system to supply other industries. These projects also have co-benefits, such as soil remediation, carbon credits, reduced mine-closure liability, reduced potential exposure to carbon tax and job creation. With carbon tax set to be implemented in South Africa from 2016, carbon abatement projects will have additional incentives beyond cost savings. Carbon tax, coupled with an 8% electricity tariff increase in the country over the next five years, means that carbon and energy savings are not only environmental considerations but also business imperatives (Kotze, 2014).

As an example, Harmony Gold Mining Company (Harmony) has developed a long-term land rehabilitation strategy linked to creating carbon sinks on mining-impacted land. Instead of following standard rehabilitation practices, such as grassing, Harmony plants species – such as sweet sorghum, sugar beet and giant king grass – which are known for their high carbon sequestration potential. Harmony's rehabilitation strategy also includes planting energy crops on mine-impacted land that has zero economic value. Once harvested, these crops can converted into renewable energy, in the form of biogas, through an anaerobic digestion process. The biogas will be used to replace fossil fuels in Harmony's metallurgical plants (Kotze, 2014). (It is noted that at the time of compiling this report, Harmony had planted energy crops on 100 ha of mine-impacted land, in the Free State, for the proof-of-concept project and an additional 250 ha for the ramp up of the plant. Outcomes of the trial are awaiting publication).

South Africa's DEA Working for Water (WfW) Environmental Programme is aimed at clearing and controlling invasive alien plants in key water ways in a cost-effective, yet labour-intensive manner (*pers. comm*. Carina Malherbe - DEA, 2017). However, as highlighted by Mugido *et al* (2014), the high biomass of these species presents opportunities for synergies between the clearing of the plants and the generation of biomass-based energy. In a project undertaken in the Nelson Mandela Metropolitan Municipality, Eastern Cape, the economic feasibility of using woody invasive alien plants as a source of bioenergy was investigated. The project concluded that the harvesting of these plants 'for bioenergy purposes is both financially and economically viable given the large, positive externalities associated with such an operation, namely replacing fossil fuels, clearing these species and generating employment' (Mugido *et al*, 2014).

Ultimately, as noted by Promethium Carbon (2016), access to sustainable and affordable energy services is a crucial factor in reducing poverty in developing countries. Sustainable, clean, reliable and affordable energy supply is a critical component in economic and socio-economic growth and development, and should be considered an integral component of planning for the post-mining rehabilitated landscape.

Urban development & settlement

In addition to the biophysical landscape changes induced by many land uses, construction and management of supporting physical infrastructure if often also required that in some way supports human and/or animal habitation or movement.

Dale *et al* (2000) define *settlement* as the 'occupation of land by humans, typically referring to patterns of residential use, from dispersed to concentrated, along a continuum from rural to village to suburb to city'. The term may also include supporting infrastructure and commercial land use patterns. Settlement often includes simplification of the landscape; modification of disturbance patterns; changes in soil and water quantity and quality; and altered movement of nutrients, organisms, and other elements of ecological systems.

To create opportunities for future-oriented long-term employment, new, innovative businesses require a good infrastructure - offices, commercial real estate, comfortable and aesthetically pleasing housing, as well as recreational areas and cultural facilities. In Germany, a real estate company has used its expertise to assist the conversion of former coal mining regions to industrial estates, office buildings, ski runs and other related uses. Such efforts are of particular benefit to would-be owners of small- or medium-sized businesses (Australian Bureau of Agricultureal and Resource Economics and Sciences, 2011).

In China, Ji *et al* (2011) highlight that China's rural and urban development are in a transitional stage - expectations for modern industrialization and urbanization is exceeding a traditionally agricultural-based society. Specifically, in mining areas, the need to provide land uses that can contribute to this new demand has been identified as a priority in land planning towards maintaining regional stability and security. This is a good example of urbanization as a key land use driver.

From a post-mining landscape perspective, at least the following aspects become relevant when considering integration of human settlement / urban development areas:

- Availability of jobs, with an estimation of the future developments, and the post-mining population's age structure to contribute to the job pool;
- Optimisation of the planning of smaller-scale networks of production sites with suppliers and buyers, including the logistical demands and effects based on goods and the working population (Isolde, 2011);
- Provision, use and accessibility of educational institutions, health facilities, sport-, cultural- and administrative facilities;
- Identification and provision of utilities and other supply infrastructure which can meet the requirements of business and local people; and
- Provision of open recreational spaces. The scenic value of landscape is an important factor for the quality of life in settlement areas. More and more, recreational spaces area proving to be essential components of a positive urban lifestyle for the local population

(Roch, 2008). Hence, scenic value, in part, determines the recreational value of post-mining landscapes.

Macro-economic contribution

As highlighted in the BFAP 2015 report, historically agriculture and mining have played instrumental roles in shaping the patterns of economic development in South Africa. "Although their contribution to gross domestic product (GDP) has shrunk significantly as the economy has developed over time, these two industries remain at the heart of economic growth and the creation of job opportunities for unskilled workers. The decline in the two sectors' contribution to GDP in relative terms should not be viewed as a decline in their importance, but rather as a testimony to the degree of industrial diversification that was made possible because of these two sectors' historic and current contribution to the economy" (BFAP, 2015).

Possibly one of the biggest challenges facing areas where GDP-contributing mines are approaching decommissioning and closure is the creation of alternative livelihood opportunities for the people who will remain in the area into the future.

During mining operations, while local people employed in mining obtain direct income as mining wages, non-miners in the local communities (either family members of miners, or other community members) obtain their income through different socio-economic activities, including sales from food crops or meat, and/or other local business activities. Furthermore, wages earned by employees at mining operations are spent on goods and services produced by local people, which, in turn, increases the incomes of local populations (Kitula, 2006). Hence, mineral extraction in these areas results in development of communities in close proximity to the mine due to mining-related employment opportunities during operations. This, in turn, provides an economic base for further growth of these communities, as mine-worker spend increases.

Development of mines also usually results in development and provision of supporting infrastructure, such as at least housing, electricity, water and sewage treatment facilities. These are usually 'brick-and-mortar' commitments made as part of development of a mine's Social and Labour Plan (SLP) during the mine permitting process. Unfortunately, this often leads to the creation of long-term dependencies on the mine that are difficult to relinquish at decommissioning. These dependencies relate to not only ongoing provision of the infrastructure and related services, but also for long-term maintenance thereof. Ultimately, this results in a residual closure socio-economic risk for the mines, with uncertain long-term financial obligations. However, in a changing mine closure policy context, the abandonment of mines is no longer permitted. Legislative regimes demand that mines take responsibility for labour-sending and host communities and there is a growing ethic that mines should leave behind decommissioned infrastructure and sustainable economic arrangements that do not curtail opportunities for communities to function once a mine has gone (Stacey *et al*, 2010).

South Africa has already started experiencing the effect of 'regional' decommissioning of some major mines – for example, closure of the diamond mines along the west coast, decommissioning of gold mining activities in the Witwatersrand Gold Fields and, even, as anticipated within the Mpumalangs Coalfields in the next 10 – 15 years. Loss of livelihoods and the quick degradation of the once-booming mining towns highlight how loss of mining contributions within an area can result in failure of social and supporting systems in areas dependent on mining activities.

Hence, the operational economic role the mine has assumed in an area (even if this was not the intention) is foreseen to become a key land use planning driver when assessing the areas socio-economic dependencies and associated long-term economic contributions within the rehabilitated, post-mining landscape. As so aptly described by Cousins and Scoones (2010), all land within a mining rights' area should instead be seen as a basic livelihood asset from which multiple and diverse livelihoods may be derived.

3.3.1.3 Step 1.3. Adhering to legislation (the 'legislative driver')

The goals for post-mining rehabilitation should aim for the highest possible quality of environmental outcome, whether it is to achieve the 'original' ecosystem function or systems with different economic values from the previous land uses. This should especially be true of the mining industry which is required to establish environmental and socio-economic planning strategies for the management of the post-mining landscape which conform closely to government regulations (Doley *et al*, 2012).

The rehabilitation of land disturbed by mining is a statutory requirement in South Africa. As discussed in Section 2.3.3, mining-related land use- and rehabilitation is governed predominantly by the requirements of the MPRDA, NEMA, NWA and SPLUMA. Also, as previously discussed, as legislation currently stands, land use specifications are incorporated within dedicated rehabilitation requirements; i.e. rehabilitation needs to be aligned to a 'pre-defined post-mining land use'.

Hence, Step 1.3 of this framework assumes compliance with local and national legislation as a bare minimum. It also expects that, where corporate-specific guidelines, standards, protocols, etc. exist, these would also be used to improve rehabilitation practices towards achieving at least good practice standards.

It is noted that no matter the detail or forward-thinking approach adopted by local legislation, successful implementation and achievement of stipulated rehabilitation measures is often a function of regulator involvement and enforcement. Yet, global experience and research indicates that in many cases there is "inadequate guidance for companies on how to develop clear rehabilitation goals, plans and monitoring systems. Without clarity on rehabilitation requirements, it is difficult for companies to be confident that their rehabilitation will be deemed 'successful' by regulators" (Glenn *et al*, 2014).

Hence, when mining companies are operating under limited / non-existent regulatory) monitoring or enforcement of environmental authorization commitments, the framework assumes that corporate governance will play this role.

3.3.2 Step 2: Defining a desired post-mining land use goal

When assessing 'ideal' versus 'practical' goals in mining-related land rehabilitation, the reality is that actual post-disturbance procedures sometimes fall short of their initial ideals because of altered economic, social and/or biophysical constraints (Australian Government, 2006). Accordingly, the essential functions of the new landscapes deviate significantly from those of the pre-existing ecosystems. This results in the need to revise or amend rehabilitation plans, which can be inherently expensive or impractical.

These challenges underline the importance of innovations for evaluating ecosystem (rehabilitation) progress towards *appropriate rather than aspirational rehabilitation goals* (Doley *et al*, 2012).

Each component of Step 1 of this framework - desired rehabilitation intention, regional land use needs, and legislative and governance requirements, will result in the mine's ability to define a *desired post-mining land use goal* for the site. It is foreseen that in most cases, this goal will not encompass one particular post-mining land use, but will comprise a suite or mosaic of possible land uses.

3.3.3 Step 3: Understanding the land's capability

The upfront planning context of this framework is based on the mine's, land's and regulator's *needs*, and not purely on the biophysical capabilities of the land. However, it is noted that critical to implementation of any suite of desired land uses is the physical capability of the underlying and surrounding landscape to be able to support these uses.

To ensure healthy, productive and sustainable vegetative growth as part of the rehabilitation process, pre-mined soils need to be classified properly, removed with care and experience, and placed back carefully using strict criteria in accordance to the most appropriate position in a reconstructed landscape. Once disturbed soils are replaced and assessed, some soil will require amelioration. This amelioration is essential to address many of the soil physical restrictions; i.e. soil compaction caused by incorrect soil management activities. This is then followed by initially re-vegetating the area with a locally adapted mixture of vigorous growing grass species, to provide good vegetation cover to stabilize the soil which has lost physical structure due to excavation, soil handling and replacement followed by good post re-vegetation management (BFAP, 2015)

The above further highlights the importance of undertaking post-mining land use planning as early as possible in the mine's planning. Prior to land disturbance, there is more flexibility in the ability to design mitigation measures to counteract negative environmental and social impacts related to mining, and to align rehabilitation measures to the long-term needs of the land. Within a brownfields site, rehabilitation measures and the associated implementation of functioning land uses are restricted to the land's current capabilities. This often provides limited post-mining land use options unless, again, significant human and financial investment is made on the site.

Also, as highlighted in the above sections, optimising concurrently for several objectives requires that planners recognize lower site flexibility of some uses than others (Dale *et al*, 2000). For example, a viable housing site is much more flexible in placement than an agricultural area or a wetland dedicated to improving water quality and sustaining wildlife. Most mine sites already comprise existing land uses both within and surrounding their mining rights' areas; they are also owners of potentially usable post-mining surface and underground infrastructure.

Hence, Step 3 of the post-mining land use optimisation framework considers the need to determine whether the mine site's current land capabilities – based on previous, current or planned rehabilitation measures, can actually achieve the desired post-mining land use goal devised in Step 2.

3.3.4 Step 4: Aligning rehabilitation measures

It may appear to be relatively easy for the owners or custodians of altered land use to pursue a cheap or easy final land use insofar as it may be difficult for a regulator to insist on a higher-level outcome without detailed knowledge of the whole disturbance process and its possible outcomes. From lessons of the past, close collaboration and transparent dialogues on rehabilitation options between land owner, regulator and other stakeholders are required before a planned disturbance begins, as in an open and ongoing exchange of information where necessary changes in rehabilitation objectives may need to be explored and even tested (Doley *et al*, 2012)

As part of this framework, Step 4 enables comparison of current rehabilitation measures with the desired post-mining land use goal outcomes.

3.3.5 Step 5: Assessing rehabilitation success

The role of ongoing measurement and monitoring in rehabilitation should not be underestimated or assumed to be just another step in legislative and corporate compliance. It should be a vital part of the rehabilitation efforts that consistently informs and alters management with trigger points throughout the rehabilitation phase of a mine. Effective rehabilitation outcomes depend on the technical quality and quantity of the environmental data collected at a given site (Glenn *et al*, 2014). There is a need both to carefully monitor the progress of the physical aspects of rehabilitation (such as soil stripping, overburden handling, landform development and soil replacement) during the operational phase as well as the progress with the re-establishment of the desired final landscape's functions and services (CoM, 2007).

Rehabilitation indicators provide defensible measurements of progress towards achievement of stipulated rehabilitation measures. These indicators may involve the measurement of a single parameter or they may involve the amalgamation of measurements of several parameters into an index or model. There could also be several indicators for one objective, and/or one indicator may have relevance to more than one objective. Concurrently, some may be important over a wide area while others may have a local significance or relate to how a particular objective is to be achieved for a particular mine. However, as defined in the Australian Department of Environment and Heritage Protection's Guideline on Resource Activities (updated May 2014), properties of a good indicator are as follows:

- It has an agreed, scientifically sound meaning;
- It represents an environmental aspect of importance to society;
- It tells us something important and its meaning is readily understood;
- It has a practical measurement process;
- It helps focus information to answer important questions; and
- It assists decision making by being effective and cost-efficient.

Stipulating feasible timeframes for monitoring of successful rehabilitation also become a critical aspect in achieving sign-off of relinquishment criteria. While an agro-ecosystem could be established and brought into relatively stable production within a few years, the assembly of species, development of ecosystem structure and attainment of sustainable functionality in a native ecosystem may take decades (Doley *et al*, 2012).

3.4 Conclusion

3.4.1 Framework development

3.4.1.1 Step 1.1: Value drivers

Step 1 focuses on the components of the plethora of upfront planning domains required to be able to refine the manner in which rehabilitation measures are defined.

Figure 17 assumes the mine's desire to make a value- or ethical-based decision on the functionality of the post-mining landscape. It also illustrates the identified four 'rehabilitation intentions' derived for the framework, as well as their associated relevance to the post-mining land use planning context. It also compares possible post-mining land uses and land capabilities, as aligned to the existing South African DAFF land capabilities classes.

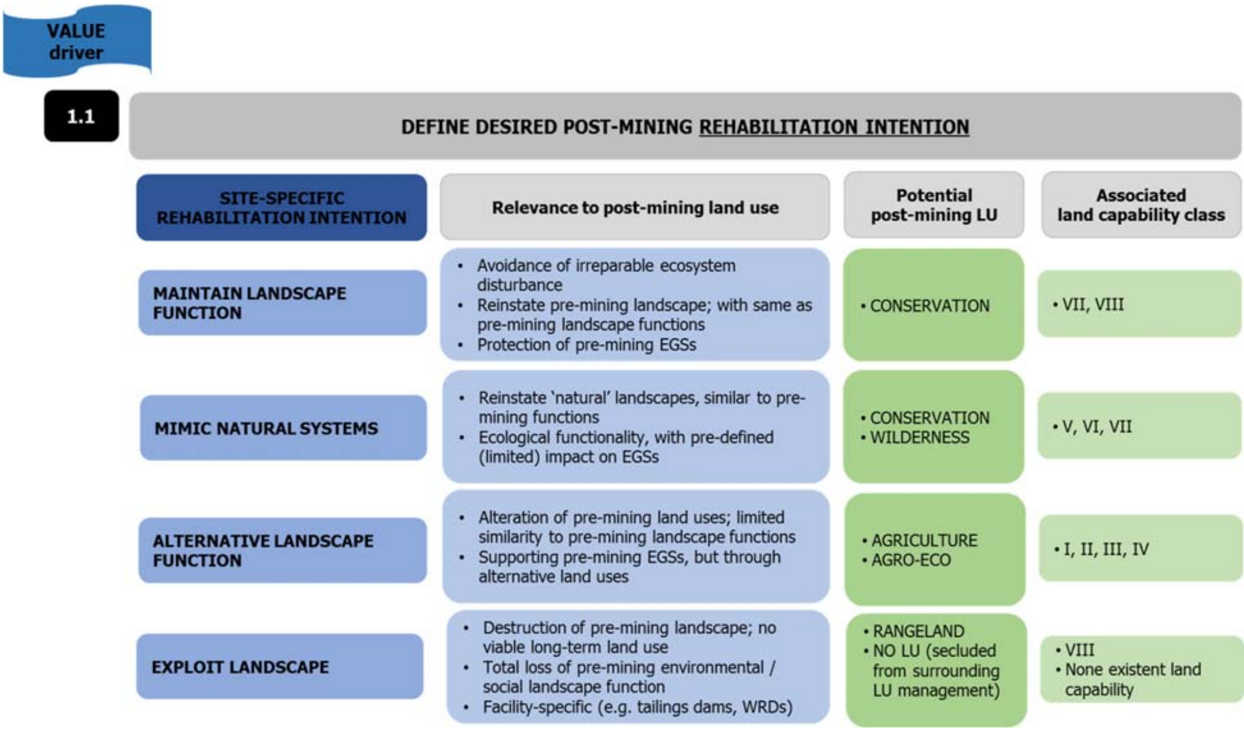

Figure 17: Step 1.1: Defining the desired post-mining rehabilitation intention (modified from Doley *et al*, 2012)

3.4.1.2 Step 1.2: Regional land use drivers

Integration of local and regional land use thinking will possibly comprise at least the following:

- Understanding the drivers for long-term water conservation, requiring consideration of treatment options/alternatives to ensure acceptable water qualities as well as volumes required to support local catchment integrity;
- Understanding the need for food security within the area, which could result in the reinstatement of productive, agriculturally based land use/s;
- Understanding the supply and demand on local ecosystem services, whether they are ecologically and/or societally or socially driven;
- Understanding current and long-term energy requirements within the area, towards identifying possible land uses that could supplement local and/or regional power and energy grids;
- Understanding human settlement patterns and local and regional spatial planning needs, to identify possible land and/or infrastructure that could contribute to rural and/or urban settlement needs; and
- Understanding the underpinning macro-economy and socio-cultural context of the rehabilitated environment, towards creation of post-mining industries that could replace or enhance the mining/industry's economic contribution and societal functionality within the area.

Consideration of the above could help towards recreating post-mining landscapes that contribute towards the long-term safety, health, function and viability of the affected communities and environments, by:

- Remediating degraded areas, polluted soils and water;
- Providing a 'safe' living environment by actively managing the potential effects of latent and residual environmental mining impacts;
- Maximising the use of existing structures and infrastructure for future social and economic benefit;
- Establishing sustainable ecosystems, with their required goods and services;
- Facilitating sustainable livelihoods of affected communities; and
- Minimising operational and rehabilitation costs.

Figure 18 therefore highlights possible regional land use drivers within the South African coal mining rehabilitation context, as underpinned by the identified needs defined in the SA NDP:

- Optimising water conservation and preservation;
- Improving land productivity (food security);
- Enhancing functional ecological systems;
- Improving energy creation and conservation;
- Supporting rural and urban development; and
- Contributing to local economies.

It is noted that there is no defined hierarchy of importance for the above, although they have been roughly prioritized in terms of Maslow's hierarchy of human needs (Figure 19). This is aligned to the aforementioned Dale *et al* (2000) suggestion that a desired landscape mosaic first be planned for according to basic human needs and then for supporting psychological supporting structures.

Each of these land use drivers represents a specific need in the South African mining-related land planning context, as described below.

In addition, this list is not exhaustive - other land use drivers could be identified for specific mining sites, each mining site will need to conceptualise its particular land use driver priorities based on local site planning requirements.

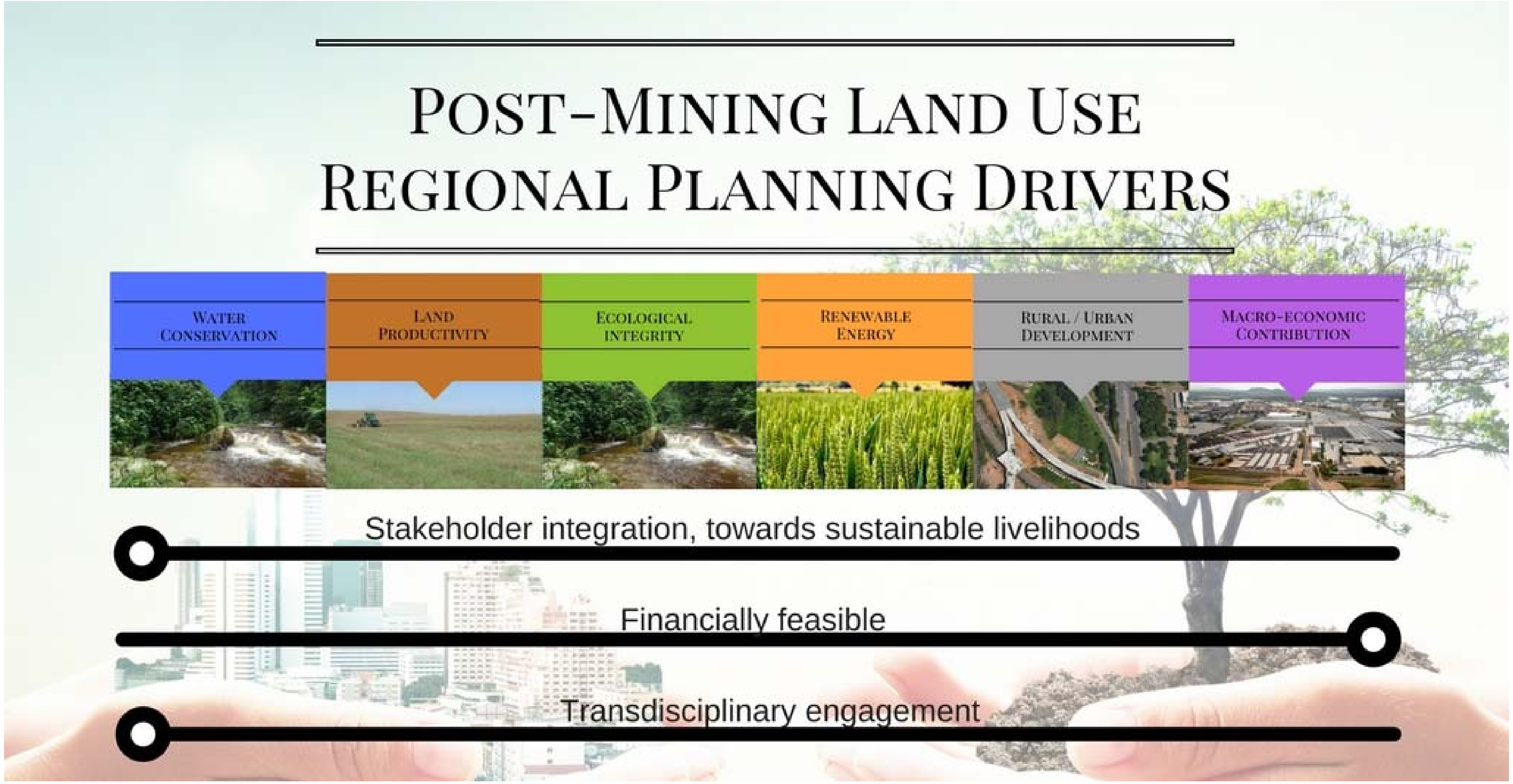

Figure 18: Step 1.2 Identified key post-mining regional land use planning drivers for the post-mining land use optimisation framework

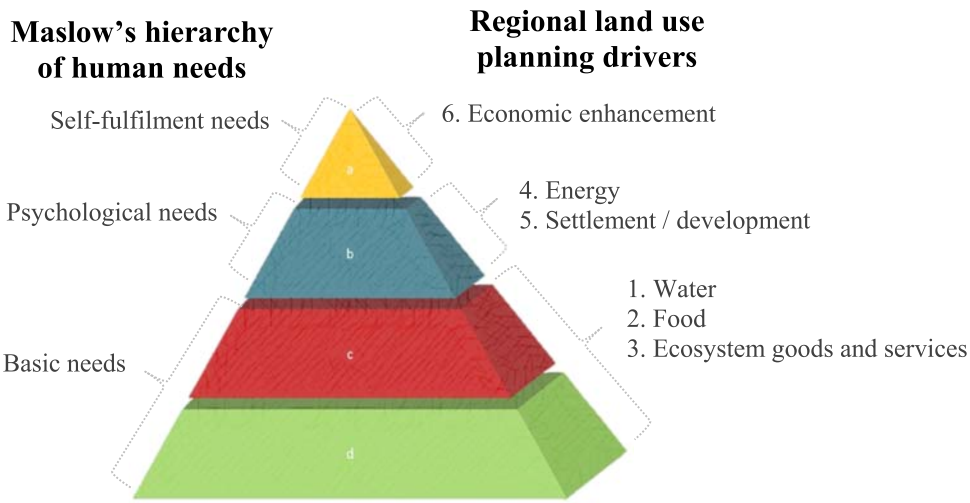

Figure 19: Land use planning regional drivers, prioritized in terms of Maslow's hierarchy of human needs

3.4.1.3 Step 1.3: Legislative planning drivers

As mentioned previously, this framework assumes compliance with local and national legislation as a bare minimum. It also expects that, where corporate-specific guidelines, standards, protocols, etc. exist, these would also be used to improve rehabilitation practices towards achieving at least good practice standards.

3.4.1.4 Step 2: Desired post-mining land use goal

The desired post-mining land use goal provides the overarching context in which rehabilitation measures for the site will be defined. It provides a consolidated, but more importantly, *justifiable* goal against which rehabilitation can be aligned. Having this goal, based on dedicated, defensible information, empowers a mine to motivate to regulators, stakeholders, shareholders, etc., why certain rehabilitation measures have been selected, and provides a sound base for ongoing and future (post-mining-related) stakeholder engagement.

3.4.1.5 Step 3: Land capability

Although land capability refers to the potential of land depending on its physical and environmental qualities (Chamber of Mines, 2007), for this framework, the following 'capabilities of the land' are considered fundamental to determining whether a pre-defined post-mining land use goal can be achieved (Figure 20):

- Physical site operational aspects, including land tenure requirements and infrastructure available to support the land use;
- Biophysical aspects, including climate, soil, vegetation, water (hydrological flow regimes and available qualities and quantities), faunal activity and air quality; and

- Social aspects, including mine-site management support and data management used to support the site's rehabilitation intention; as well as details on workforce and community abilities to support both concurrent rehabilitation and post-mining land management.

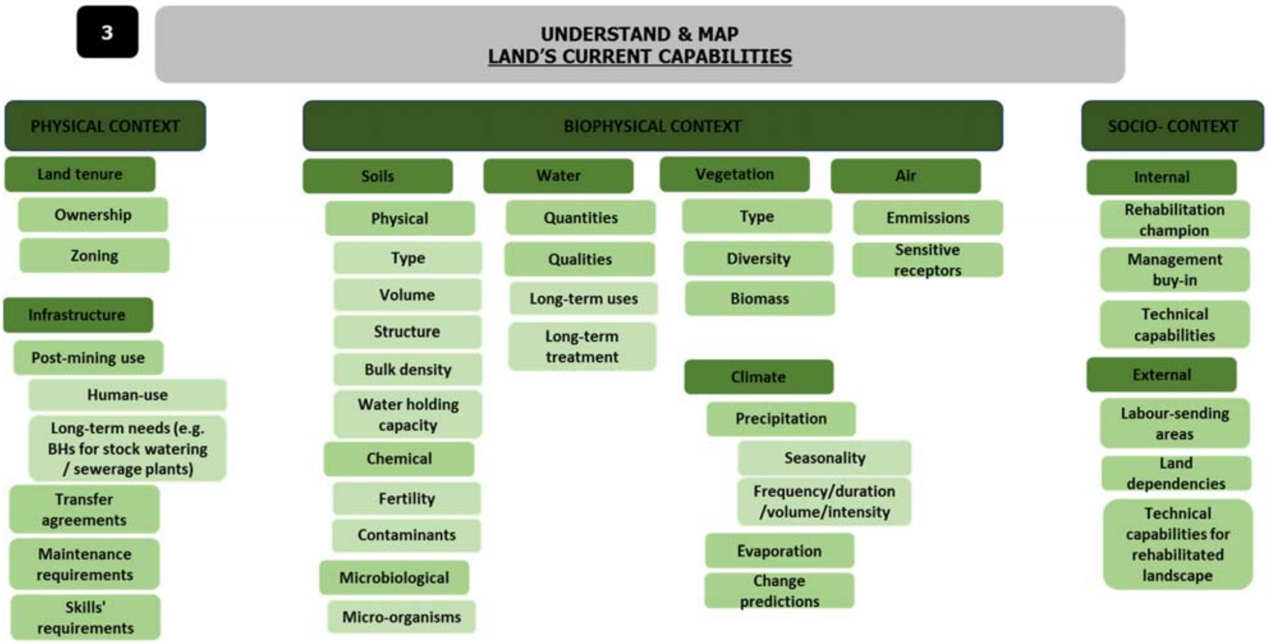

Figure 20: Summary of indicative aspects of the land's current capabilities that need to be considered as part of Step 3 of this framework

As Step 3 is an assessment of mostly quantitative data, it requires electronic mapping of the above aspects. This would not only provide a dedicated manner to document site data and associated land capability trends over time, but would also provide a dedicated facility / platform for archiving long-term information.

3.4.1.6 Step 4: Aligning rehabilitation measures

The following three rehabilitation alignment scenarios are envisaged for the framework:

- **Implement**: This scenario assumes that existing rehabilitation measures are adequate to achieve the desired land use goal, and hence implementation of these rehabilitation measures can and should continue. The framework would automatically lead the decision-making thinking to Step 5.
- **Re-rehabilitate**: This scenario assumes that the land use goal can be achieved, but that effort is required on current land capabilities and planning domains to better align the rehabilitation measures to the desired land use goal. This may require refinement of rehabilitation measures and/or inclusion of new, more appropriate measures going forward. For example, improvements to soil replacement mechanisms, refined amelioration quantities or schedules, more focused land management, etc.

- **Re-define land use**: This scenario assumes that the land's current capabilities cannot and will never be able to achieve the stipulated land use goal. It implies that commitments made for the post-mining land use/s are unfeasible and/or impractical. Or, that achievement of the land use goal would be financially unfeasible for the company. Ultimately, a new post-mining land use goal would need to be defined, more closely aligned to what the land capabilities can achieve. For brownfields sites, this suggests that Regulators would need to be informed of the potential non-compliance to EMP commitments, as well as provision of a suitable alternative post-mining land use and associated rehabilitation plans.

Again, this Step of the framework highlights that the sooner land use planning is incorporated within mine planning, the greater fluidity in the decision-making process for feasible rehabilitation measures available to the mine. Having a post-mining land use goal against which to stipulate and defend required rehabilitation measures is much easier and more time- and cost-effective than having to try retrofit disturbed land capabilities to a desired outcome.

3.4.1.7 Step 5: Rehabilitation success

Monitoring of rehabilitation success as early on as possible also enables adequate time for implementation and outcomes assessment of research trials and/or other studies that may be required to improve the site's rehabilitation achievement knowledge. Outcomes of improved site knowledge empowers the operation to refine rehabilitation measures and/or apply suitable corrective action, as required. This also enables closure of knowledge gaps that may hinder development of suitable relinquishment criteria.

For eventual mine site relinquishment, setting of suitable relinquishment criteria (also referred to as completion criteria) provides a defensible benchmark against which success of rehabilitation can be measured. As for the rehabilitation indicators, relinquishment criteria should be measurable and accurate, and should be signed-off by regulators.

Ultimately, regular review, modification and refinement of rehabilitation approaches, methods and monitoring procedures is required to ensure that the rehabilitation process remains effective, towards achievement of the desired post-mining land use goal.

3.4.2 Non-negotiables: social enhancement, financial feasibility and transdiciplinarity

Development of this framework assumes the following three fundamental, non-negotiable planning aspects:

- Any post-mining land use planning must *take into consideration the needs of the stakeholders that will remain* in the area after rehabilitation (communities, commercial entities, etc.), as well as the stakeholders responsible for the long-term land planning, implementation and custodianship of the post-mining landscape. This ultimately implies a need to *restore sustainable livelihoods* to the post-mining landscape;
- The rehabilitation measures needed to create the landscape for the identified post-mining land use/s need to be *financially feasible* for the mining operation; and

- Any mining-related planning *requires integration of inputs, knowledge and experience from a transdisciplinary team*, towards achieving the best possible outcome for the post-mining landscape state and functionality.

(It is noted that as these are 'underlying non-negotiable' aspects of the framework, they do not appear as individual components in the framework. All decisions made as part of the individual steps of the framework are assumed to take cognizance of these asepcts).

3.4.2.1 Restoring sustainable livelihoods

Mining best practice requires companies to improve, or at least restore, the livelihoods and standards of living of displaced persons. A *livelihood* is defined as a means of securing the necessities of life (ICMM, 2015). Currently, there is increasing recognition that livelihood rehabilitation requires a focus beyond just income, and that other social factors such as education, health and social cohesion serve to sustain living standards over time (ICMM, 2015).

To optimise the potential for restoring post-mining sustainable livelihoods (social enhancement and regeneration opportunities), the framework assumes that the following basic social planning principles (adapted from Krause & Snyman, 2014) underpin identification of the post-mining land use/s:

- Land use-, and associated rehabilitation planning, will *consider the interests, values and way of life of the host communities*. This will include an ongoing, reiterative engagement process throughout the mining life-cycle, until eventual site relinquishment by the mining house.
- All mining communities are affected by different socio-economic, environmental and political factors, and hence land use- and rehabilitation planning cannot follow a one-size-fits-all approach, and will *identify site-specific challenges*. Taking local knowledge into account will empower decision -makers with a good understanding of their particular socio-ecological landscape and related impacts of mining.
- Engagement will take place in a manner that *accurately transfers accessible information to local communities* in such a way that they have a good understanding of processes, impacts, options, etc., and hence can provide informed input to the planning processes. This can assist in narrowing gaps in frames of reference when engaging with local stakeholders, reinforcing misunderstandings between mining officials and communities (Krause & Snyman, 2014).

The above does not imply that mines allow stakeholders to dictate specific post-mining land use/s for the rehabilitated site. Instead, it implies creation of a long-term partnership between current and future land custodians.

Ongoing engagement will support transparent, proactive sharing of information throughout the mining life-cycle, to the benefit of both the mine and stakeholders. Post-closure land uses are far more likely to be supported by local stakeholders in the long-term if they have a voice in the decision-making (ICMM, 2006). Robust engagement could further enhance the mine's social license to operate, which could be the difference between the mine's ability to eventually relinquish the site, or having to remain a land owner into perpetuity.

3.4.2.2 Financial feasibility

Mining operations are finite economic activities, which are usually relatively short-term. Within this finite timeframe, the company's business imperatives are ultimately focused on reducing debt, maximising growth or production, and minimizing environmental and social liabilities, as illustrated in Figure 21 (*pers. comm*. Clinton Lee, South32, 2016).

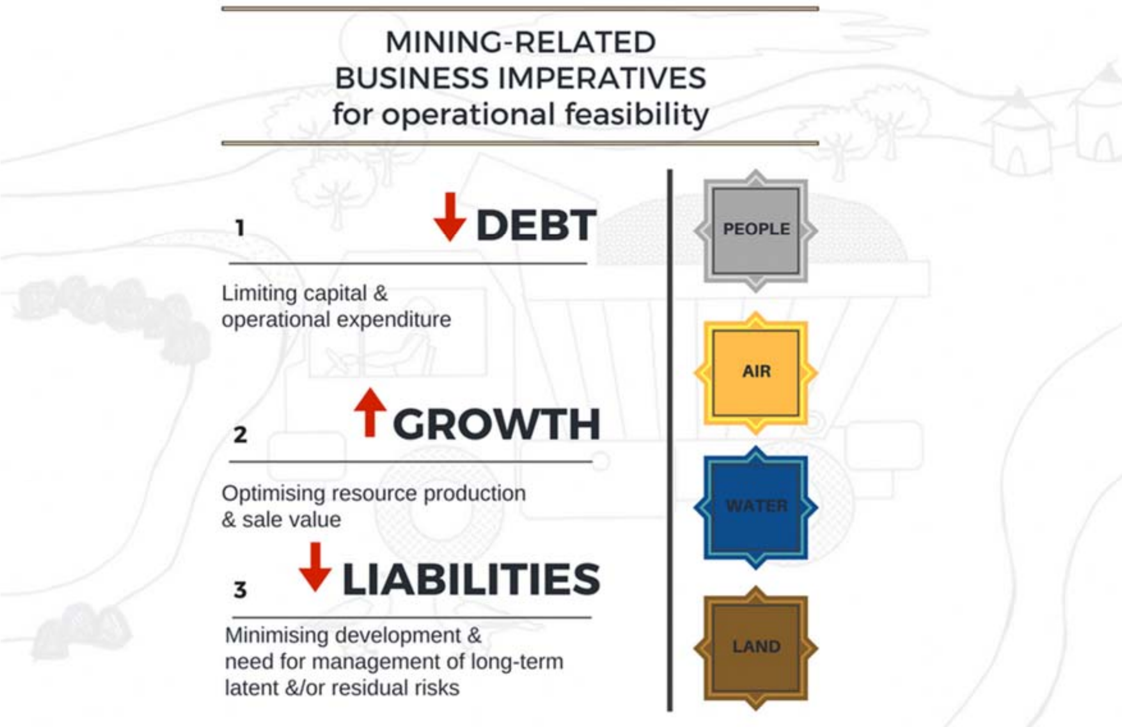

Figure 21: Mining-related operational business imperatives

Although society is becoming more vocal on expectations on mines, both during operations and on the rehabilitated landscape, it is noted that mining companies are operating within the business imperatives of any other commercial company. Hence, it would be unrealistic to assume that implementation of a post-mining land use goal superseding a rehabilitation intention of 'maintaining ecological function' across the entire site is feasible.

Soltanmohammadi *et al* (2010) highlights the example of the Blayney Copper Mine of Australia whose primary rehabilitation objective was to remediate the site to a level suitable for residential land use, given the proximity of the site to the town of Blayney (NSW Minerals Council, 2006). However, the high level of investigation and remediation required to achieve residential standards was cost prohibitive. Parks and open space land uses were subsequently adopted, ensuring that the site would be safe for occasional use by the local community and grazing livestock.

As another example, Alexander (1996) notes that the original aim of reclamation at Jos Plateau of Nigeria was to restore the mined areas for agriculture. Based on a series of trials to assess how this could best be achieved, it was agreed between the mine and regulators that it was both impractical and uneconomical to attempt to raise the fertility of the reclaimed spoils to the point at which it could sustain traditional arable agriculture. Hence the alternative policy of establishing eucalypt plantations was introduced.

Should rehabilitation and land use expectations on a mine exceed its productive site value, there is also a risk that the mine would undergo unscheduled closure, resulting in limited / no rehabilitation of the land. Hence, although, in the interest of future generations, mines should be expected to aim towards a rehabilitation intention of highest possible ecological, social and economic value, implementing specific post-mining land uses needs to be financially feasible to the company.

3.4.2.3 Transdisciplinary teams

Planning for mine closure requires the focused attention of a multitude of stakeholders and disciplines to meet these needs, both present and future. At the mine and governmental level, the desire for optimised financial performance drives the operational efficiency and its subsequent profitability; the need for regulatory compliance drives risk management through minimisation of long-term environmental impacts while the focus on sustainable long-term livelihood creation is guided by the mine's social license to operate. But how does one reach an inclusive consensus between all the stakeholders involved that still meets the principles of sustainability?

Rehabilitation brings with it a need for a new set of skills; skills that are not necessarily taught at mining institutes, or even within the mining industry. The creation of a positive post-mining legacy requires the understanding of what exists (the properties of materials available for rehabilitation), of what we can do with what exists (the capabilities of these materials) and what we want to do (the desired final land outcome). This is all underpinned by key moral/value-driven decisions that guide how we do it. Mining land use, rehabilitation and closure planning hence requires a crossing of many disciplinary boundaries and through different levels of disciplines - from the empirical level towards a pragmatic level, continuing to a normative level and all the way to the value level – a true transdisciplinary approach. Acceptance of such a transdisciplinary approach implies the integration of rehabilitation-, land use- and closure planning with operational mine planning from project conception. It also implies the need for integration with other stakeholders throughout the mine life cycle, including management, production, environmental disciplines, community stakeholders and the environment itself.

To be able to meet the principles of sustainability in mine rehabilitation and closure planning requires a major transformation of the objectives on which decisions are based, and an evolving understanding of the complex inter-relationships between the existing as much as the future ecological, economic and social factors. There is a clear need to redefine the education of mine closure practitioners and enhance their abilities to work in a transdisciplinary environment, to develop a new framework for the design, planning and management of land that will take into consideration current complex socio-economic conditions and to provide the context for land management in conditions of uncertainty including social, environmental, operational and economic aspects.

Mine land use-, rehabilitation and closure planning hence requires a true transdisciplinary, collaborative approach. Challenges, solutions and actions should be co-defined, co-created and co-delivered, towards creating a landscape that is 'owned' by the people accountable for its long-term socio-ecological regeneration and growth.

3.4.3 Preliminary post-mining land use optimization framework

The literature reviewed as part of this study has indicated that intense competition for land as populations grow, uncertainty in development and management of long-term residual and latent mining-related risks, coupled with uncertain rehabilitated land's future productivities and ecological services in changing climates, gives rise to a significant challenge in post-mining land use and associated rehabilitation decision-making. The issue is compounded by historically unfeasible EMP land use commitments, and the significant associated cost of amending or refining many current rehabilitation decisions.

A decision-support framework to assist mining teams identify the most suitable post-mining land use options against which rehabilitation measures can be aligned has therefore been identified as being critical to a successful site rehabilitation trajectory.

Based on the aforementioned literature and structured framework thinking, Figure 22 illustrates each key step in the decision process, summarising the process-flow identified as part of this study. The preliminary *post-mining land use optimisation framework* provided in Figure 22 underpins the need for examining site-specific decisions within the regional land planning context as well as in relation to the social, economic and political perspectives within the mine's localised planning domain. These decisions could alter the manner in which the desired (target) post-mining land use is defined and, ultimately, the manner in which human and financial capital is spent in defining and implementing site-specific rehabilitation measures.

This preliminary framework was used to engage with industry members, against which its feasibility could be assessed.

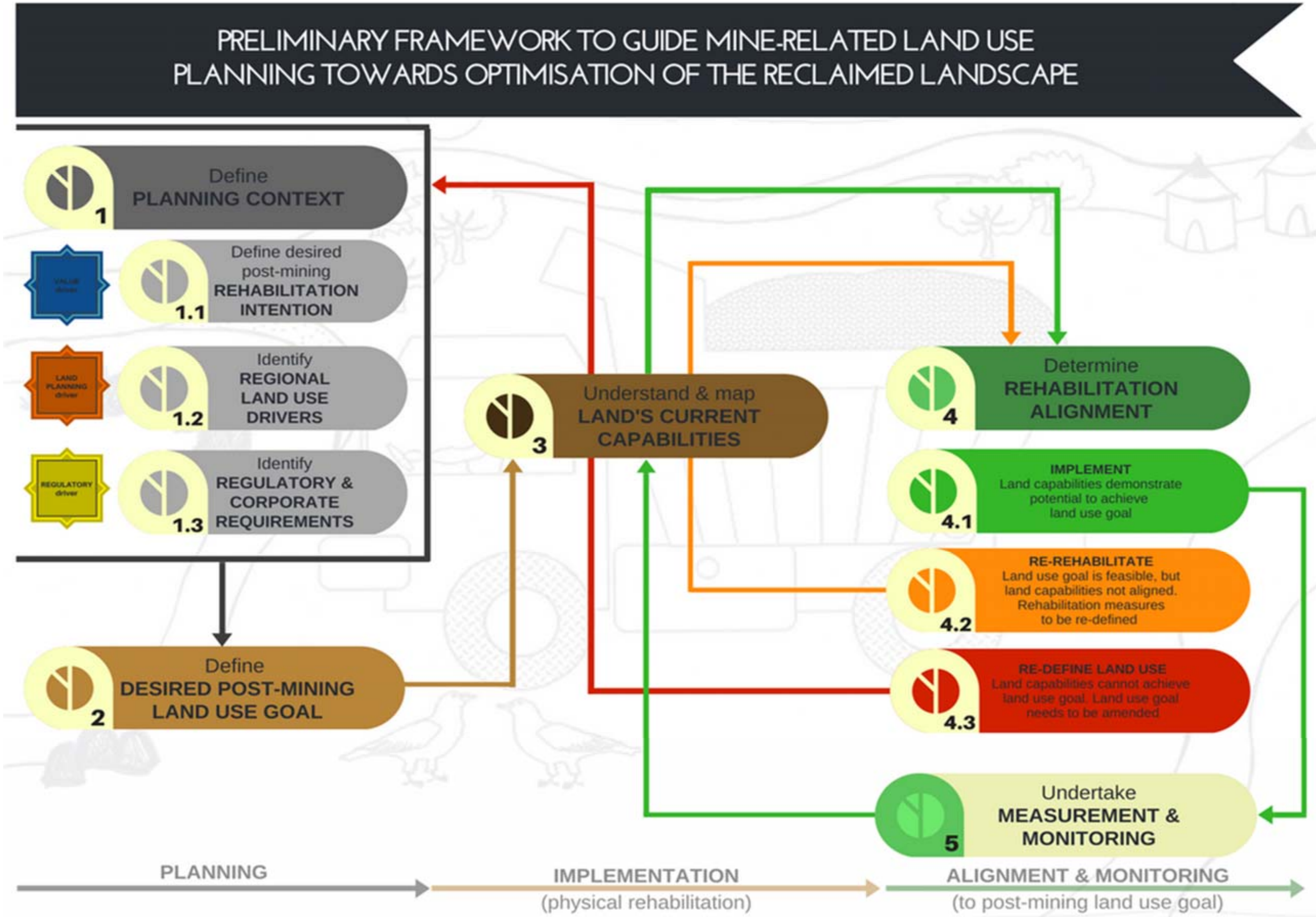

Figure 22: Devised preliminary post-mining land use optimisation framework

CHAPTER 4: POST-MINING LAND USED OPTIMISATION FRAMEWORK INDUSTRY PERSPECTIVE

4.1 Introduction

South Africa's economy is highly fossil fuel dependent, with the main source (91%) of electricity being coal. Apart from the heavy domestic reliance on coal as a source of energy, South Africa is a significant participant in global coal markets. The majority of South Africa's reserves and mines are in the Central Basin, which includes the Witbank (eMalahleni), Highveld and Ermelo coalfields. South Africa's economically recoverable coal reserves are estimated at between 15 and 55 billion tonnes and coal production in the Central Basin is likely to peak in the next decade (Bench Mark Foundation, 2014).

In order to determine the feasibility of the preliminary post-mining land use framework conceptualized in Chapter 3, the viability and relevance of the framework within the SA coal mining industry needs to be assessed. In addition, the actual pertinence of the conceptualized Step questions need to be determined, as well as whether or not significant decision-support questions have been omitted or not yet defined.

Hence, this Chapter focuses on assessing the relevance of the preliminary post-mining land use optimisation framework, as gauged from an industry perspective. It provides the noteworthy findings of one-on-one discussions held with specific Coaltech coal mining members, in the form of a dedicated questionnaire. The Chapter culminates in the provision of a final post-mining land use optimisation framework as the outcome of this study. This final framework combines the above findings, new questions and refinements of the preliminary framework conceptualized in Chapter 3.

4.2 Methodology: gauging industry perspective

4.2.1 Interviews and questionnaires

As this study has been funded by Coaltech, five of the research organization's key member mining companies were targeted to provide an industry perspective on the preliminary framework. Each of these companies is considered a 'major' mining house within the SA coal mining industry. Also, each of these companies has significant operations – planned, operational and/or decommissioned or closed within the Mpumalanga Coalfields, around which the framework was contextualised.

In addition, as land use thinking is paramount to mining-related rehabilitation planning, the people responsible for- or with vested interests in the rehabilitation planning and implementation phases were identified for assessment of the preliminary framework. Each of these team members, due to their positions in the companies, were deemed as suitably qualified and experienced in representing the perspectives of their associated companies.. Although it is important to note that there may be varying opinions across each company, due to the interviewees' current positions in the companies as well as previous experience, the responses are deemed representative of the company philosophies and approaches. Hence, although the sample pool of five companies could be considered to be relatively small, representation of their companies (in their respective roles) was deemed sufficient to gauge the necessary 'industry perspective'.

One-on-one meetings (industry interviews) were held with individuals of each of the above companies at predetermined dates. Table 8 provides the five companies, focus- and years of interviewee experience, as well as the date the discussion took place.

Table 8: Mining companies and associated employees with which the preliminary framework was discussed

Mining company	Focus of experience of interviewee	Years of experience of interviewee	Date of discussion
Company A	Rehabilitation; land management	21	26 April 2017
Company B	Rehabilitation; closure; post-mining land management	18	3 May 2017
Company C	Environmental, rehabilitation, closure	12	4 May 2017
Company D	Business sustainability; mine closure	42	24 April 2017
Company E	Environmental; rehabilitation; mine closure	12	24 April 2017

During the meetings, a brief presentation of the preliminary framework was provided to explain the rationale behind its development. A questionnaire was then undertaken with the person, to gauge their perspectives on key elements of the framework. This questionnaire comprised the following:

- Company and person-specific information – this was deemed necessary to verify the level of input for the received industry perspective;
- 20 pre-defined questions, of which 17 questions focused on the framework's content and the remaining 3 questions on the framework's structure;
- A final section where further comments not already addressed could be documented.

Questions were grouped according to each step in the framework; with each step highlighted in a different colour for ease of reference.

Table 9 provides the layout of questionnaire addressed as part of gauging the industry perspective on the preliminary framework.

Table 9: Layout of questionnaire addressed as part of gauging the industry perspective on the preliminary framework

FRAMEWORK TO GUIDE MINING-RELATED LAND USE PLANNING TOWARDS OPTIMISATION OF THE REHABILITATED					
INDUSTRY PERSPECTIVE ON PRELIMINARY FRAMEWORK					
	Date of discussion				
	Name of mining company				
	Person with whom discussion was held				
	Designation				
	Position in company				
	Years of experience				
	Focus of experience				
	Question	**Response**			
		1 YES	**2 MAYBE**	**3 NO**	**Comment**
	Framework content				
	Step 1				
1	Does your company have a dedicated rehabilitation strategy that guides mine-wide rehabilitation planning?	1	0	0	
2	Is defining a post-mining land use incorporated as a key component in company rehabilitation planning?	1	0	0	
3	Is there a team member dedicated to rehabilitation planning ('rehabilitation champion') on each mine?	1	0	0	
4	Does the company have a clearly defined rehabilitation intention against which site planning can take place?	0	1	0	
5	Have the regional land use needs in which the mines are operating, as defined in this framework, been identified and incorporated in rehabilitation planning?	0	0	1	
6	Are the mines getting support and guidance from regulators in defining post-mining land and associated rehabilitation needs?	0	0	1	
7	In your opinion, do you agree that devising a suitable post-mining land use should be a key component of rehabilitation planning?	1	0	0	
	Step 2				
8	Does each site have a clearly defined post-mining (land use, rehabilitation or closure) vision?	1	0	0	
9	If there is a post-mining vision, has this been devised by a transdisciplinary team?	1	0	0	
10	Is there an awareness within the mine teams responsible for rehabilitation implementation (mine manager, planners, environmental personnel, contractors, etc.) of the site's post-mining vision?	1	0	0	
11	Have rehabilitation measures been specifically defined to achieve this vision?	1	0	0	
	Step 3				
12	In your view, will the current land capabilities of operational mines be able to achieve authorised EMP land use commitments?	0	0	1	
13	Would areas that have already been rehabilitated be able to support any type of functional post-mining land use/s, regardless of EMP land use commitments?	0	1	0	
	Step 4				
14	Is it foreseen that areas that have already been rehabilitated would require refinement of existing rehabilitation measures and/or corrective action to achieve current EMP land use commitments?	1	0	0	
15	Is there a general awareness at the mines of the cost, time and human capital required to 're-rehabilitate' areas, should this be required?	0	0	1	
16	If the general awareness noted above is present, has the company started engaging with in-company decision-makers and/or regulators on the need to re-define rehabilitation commitments?	0	1	0	
	Step 5				
17	Is measurement and monitoring a key component of rehabilitation success determination?	0	0	1	
	Framework structure				
18	Does the flow (step-wise approach) of the framework make sense?	1	0	0	
19	Is the layout and content comprehensive enough to guide planning thinking at the mines, across all team levels, yet simple enough not to be tedious?	1	0	0	
20	Would inclusion of this type of framework into your company's mine planning - greenfields or brownfields, improve the manner in which rehabilitation measures can be devised?	1	0	0	
	Further comments				

4.2.2 Qualitative data analysis

Qualitative research is defined at the "development of concepts which help us to understand social phenomena in natural (rather than experimental) settings, giving due emphasis to the meanings, experiences and view of the participants" (Pope & Mays, 1995).

Table 10 provides key aspects of qualitative research analysis methods, and their outcomes. It also provides relevance to this study, motivating use of the method.

Table 10: Key aspects of qualitative research analysis methods and subsequent outcomes, and associated relevance to this study

Aspect	Qualitative	Relevance to this study
Purpose	To describe a situation and/or gain insight to a particular practice.	To explain the thinking behind the preliminary post-mining land use optimisation framework to interviewees, and gain their opinions on its approach, industry relevance, content and structure.
Format	No pre-determined response categories.	20-question simplistic questionnaire.
Data	In-depth explanatory data from a small sample.	Five key coal mining companies operating within South Africa. All considered 'major miners', and supportive of the Chamber of Mines' Coaltech projects.
Analysis	Draws out patterns from concepts and insights.	Questionnaire approach enables comparative analysis of responses to determine recurrent themes or focal points across the 5 mining companies' responses.
Result	Illustrative explanation and individual responses. Produces results that generalize, compare and summarise.	Individual and cumulative results could be simplistically graphically illustrated. Interpretation of discussions around individual questions could also be undertaken.
Sampling	Theoretical.	The preliminary framework was developed based on an in-depth literature review. Hence, the questionnaire was developed based on key findings gauged from this literature review.
Research question	Fixed; focused.	Is there value in the framework, and can its use improve the manner in which on-site rehabilitation can be planned and implemented?
Expected outcome	Identified in advance.	Critique of preliminary framework, towards being able to develop a final framework.

As a qualitative data analysis approach was adopted to assess the results obtained from the industry perspective discussions, focus was placed on 'interview' content analysis, towards testing the preliminary framework structure, content and industry relevance. Furthermore, a *deductive content approach* to the interview data was used – according to Cresswell (2009), *content analysis* is the procedure for the categorization of verbal or behavioral data for classification, summarisation and tabulation. Content analysis considers both what the data is, and what was meant by the data. Hence, this approach allowed for compilation of a pre-defined questionnaire that could be used as the basis for verbal discussions with the interviewees. The questionnaire also served the function of grouping interview data, against which similarities and differences between the interviewees could be gauged. This approach is usually used when qualitative research is a smaller component of a larger study (Nigatu, 2009).

During the interviews – which took place over a week period (24 April to 5 May 2017), the following aspects were focused on towards being able to process the information in a valuable way (http://qualitativeresearch.ratcliffs.net/15methods.pdf, accessed on 10 May 2017):

- The main *intent of the content* the interviewee was trying to get across;
- The *attitude* of the interviewee towards the discussion content;
- Whether the content of the message was meant to represent an *individual or company view*; and
- The degree to which the interviewee was representing *actual versus hypothetical* experience.

4.2.3 Assessment of qualitative data

Once the five interviews were held, the responses obtained in the questionnaires were used to determine the range in responses to each question, and to identify specific recurrent themes or focal points. Aligned to the above qualitative analysis processing of information guidance, interviewee responses were captured in the following two ways –

1. Allocation of one point for an affirmative indication to either a Yes, Maybe or No response. This was aimed at trying to simplify responses, and gauge the main intent of the content the interviewee was trying to get across. It was also used as a method to more simply align responses gained from all interviewees, towards being able to comparatively analyse the outcomes; and
2. Allowance for discussion on each question, during which the interviewee's attitude and perspective (based on experience) could be captured.

Prior to the interviews taking place, the following challenges associated with accurate interpretation of the interview data (https://www.slideshare.net/tilahunigatu/qualitative-data-analysis-11895136, accessed 15 May 2017), were contemplated:

- A reliance on first impressions;
- A tendency to ignore conflicting information;
- Emphasis on data that supports the preliminary framework; and
- Ignoring unusual information/opinions.

The above was seen as being particularly important to consider as the interviewer already had a working relationship with all of the interviewees, as well as a working knowledge of most of the company's rehabilitation and mine closure approaches. To ensure the captured results remained as objective as possible, interviewees were requested to again critically review the questionnaire results captured during the interviews prior to eventual data analysis being undertaken. This took between two and four weeks after the interviews were held (May – June 2017), with final questionnaires submitted electronically to the interviewer for inclusion as part of this study.

Assessment of the cumulative results was undertaken by consolidating the number of points allocated for each 'yes' answer, per question. The higher the cumulative 'yes' value of the question (with 5 being the highest, and 0 being the lowest), the higher the documented significance of that particular question. These 0 – 5 cumulative responses where then converted to a percentage of the number of respondents noting a 'yes' answer, to gain a clearer outlook of the results.

4.3 Results: gauging industry perspectives

The following section provides the key discussion points and relevant outcomes of the industry interviews.

4.3.1 Consolidated questionnaire outcomes

As there is no direct relevance to which interviewee (and associated company) held which perspective, the results provided in this section are not company-specific. More importantly, the cumulative results of all five perspectives have been assessed. This has assisted in gaining an understanding of similarities and/or variances in currently industry thinking. However, for study completion, the individual questionnaires, minus interviewee information, are provided in Appendix A.

Figure 24 provides the cumulative 'Yes' results, per question, graphically illustrating individual question outcomes. The colours in the bar graph reflect the associated framework step colours, as provided in Table 9.

The responses to the individual 20 interview questions, and the cumulative result of each answer, indicated as Yes, Maybe or No are provided as part of the summary discussion.

Figure 23: Summary of the key outcomes of the industry interviews on the preliminary post-mining land use optimisation framework

4.3.2 Discussion outcomes

The following is a summary of the key discussion outcomes gained during the interviews held with the Coaltech mining companies on the preliminary post-mining land use optimisation framework.

4.3.2.1 Framework content

Step 1: Upfront planning (questions 1 to 7)

The cumulative responses to the Step 1: upfront planning questions are summarised in Table 11.

Table 11: Cumulative responses to the Step 1: upfront planning questions

No.	Question	Interviewee response (percentage %)		
		Yes	Maybe	No
1	Dedicated company-specific rehabilitation strategy	60%	0%	40%
2	Define post-mining land use upfront	80%	20%	0%
3	Dedicated rehabilitation champion on each site	40%	0%	60%
4	Clearly defined rehabilitation intention	40%	40%	20%
5	Considered regional land use needs	20%	0%	80%
6	Support from regulators on post-mining land use	0%	0%	100%
7	Post-mining land use should drive rehabilitation planning	100%	0%	0%

1. Three of the five companies have a dedicated company-wide rehabilitation strategy that guides mine-wide rehabilitation planning. Of the strategies in place, these vary in comprehensiveness and focus, but are expected to be complied with by all the mines. The two companies indicating no such strategy placed firm emphasis on the need for the mines' EMPs to play this role, and noted no need for 'yet another document'. The EMP is the document on which an Environmental Authorisation has been approved, and it was noted that the EMP should provide this overarching rehabilitation guidance.
2. It appears that most of the companies acknowledge the importance of upfront land use planning, with four of the five interviewees noting the need to define a post-mining land use to guide conceptualisation of rehabilitation measures. However, there was consensus that the terminology for land capability and land use is still often incorrectly applied, with most upfront rehabilitation planning focusing on land capabilities. This results in a biophysical rehabilitation focus (soils and vegetation specifically).
3. Only one of the five companies incorporate regional land use drivers in their planning. However, this was also the only company openly acknowledging that they were not planning for a 'walk away' mine closure scenario and hence are developing opportunities for alternative land uses on previous mined-out land which need to be linked to regional land use needs.

4. Only two of the five companies indicated the presence of dedicated rehabilitation champions on each mine site. And these were present often only on mining sites nearing decommissioning. In most cases, this responsibility lies with the environmental officer. However, rehabilitation is then just one of many responsibilities for this person, resulting in limited time, energy and effort available for dedicated rehabilitation planning.

   All interviewees noted that on those sites where there is a rehabilitation champion, rehabilitation success is notably higher. In addition, most of these rehabilitation champions have an agricultural and/or farming background. As many of the rehabilitated landscapes have identified agriculture-based post-mining land uses, these agronomic skills and capabilities, (and vested farming interest in getting functional capabilities off the rehabilitated land) appear to be indicative of rehabilitation success.

5. Only two of the five companies indicated a clear company rehabilitation intention, as defined in the preliminary framework. However, all the interviewees agreed that the companies' planning is underpinned by such intentions, regardless of whether it has been documented or not.

   Interestingly, there appeared to be two distinct rehabilitation 'intentions' – one driven by legal compliance and operational financial viability, and the other by the need to 'do the right thing'. For the former, the discussion was around mining companies' core business of mining - the regulatory driver is perceived to be of utmost importance, followed by production-related financial gain to the benefit of company shareholders. However, the argument for the 'value driver' was that the provision of a Mining Right implies a certain amount of responsibility to mitigate and manage mining-related impacts. Of which implementing functional post-mining land uses is key. Hence, there is an expectation that rehabilitation will be done to the highest possible standard, towards improving land functionality that can be maintained over time.

   In addition, it was noted that even for those companies with an overarching legislative driven intention, the way in which rehabilitation is undertaken on-site is often highly dependent on the personal drivers of the specific mine manager and/or rehabilitation team member - where rehabilitation is a passion within the specific team, the rehabilitation intention has a definite 'do the right thing' component.

6. All five interviewees unanimously agreed that there is a lack of support and guidance from regulators in defining post-mining land and associated rehabilitation needs. Even on sites where interactions with regulators are taking place on a frequent basis, this is more from an environmental authorisation compliance perspective. No guidance, support and/or suggestions are offered, towards improving site management. This is often due to significant, constant change in regulatory personnel, which makes it difficult to establish relationships that could guide such planning. This is further complicated knowing that there are varying regulatory role players in rehabilitation,

with varying levels of understanding of complex rehabilitation aspects and varying levels of regulatory input.

Although South African mining-related rehabilitation regulations are world-class, often the post-mining land functions aspects focus on health & safety more than actual long-term land function. Hence, when on-site, regulators appear more concerned with a site's long-term health & safety needs (void access, fencing, quality of decanting water, etc.) than helping guiding viable rehabilitation measures or post-mining land uses.

There is also a perception that even the regulators are not aware of regional land use drivers which complicates the way the context for post-mining land use planning can be set.

7. All five interviewees agreed that the post-mining land use should guide rehabilitation planning. Some form of land functionality is required to ensure a post-mining land use; without a clear vision as to what needs to be achieved, it is difficult to ensure rehabilitation measures will be successful.

Step 2: Post-mining land use goal (questions 8 to 11)

The cumulative responses to the Step 2: post-mining land use goals' questions are summarised in Table 12.

Table 12: Cumulative responses to the Step 2: post-mining land use goals' questions

No.	Question	Interviewee response (percentage %)		
		Yes	Maybe	No
8	Clearly defined post-mining land use vision for each site	100%	0%	0%
9	Vision defined by transdisciplinary team	60%	0%	40%
10	Mine-wide awareness of post-mining vision	60%	20%	20%
11	Rehabilitation measures defined in terms of post-mining vision	80%	20%	0%

8. All of the interviewees indicated that a closure vision for the mines was available. Most of these visions were stipulated as part of the mines' EMPs and included some form of post-mining land use commitment. In general, it was acknowledged that many of these visions are very general and lack detail. This could be assigned to the long-term nature of mining contracts, many which span over periods longer than 30 years. On some mines there are dedicated engineering landform designs reflecting the planned final rehabilitated surface topography and soil replacement sequence – this is directly aligned to a post-mining land use goal.
9. Where generic closure / land use visions are included just as part of the EMPs, the visions appear to be devised by the consultant having compiled the EMP. However, on those sites with dedicated post-mining rehabilitation designs, the visions are

defined by multi-disciplinary teams. This includes in-house mine and environmental planners, regional teams, consultants and executive management.

10. As for Question 9, in those mines with generic EMP closure visions, only teams directly responsible for environmental matters are aware of the post-mining vision. In those mines where the vision has been devised as a group effort, this vision filters throughout the company as a common goal. However, it was clearly noted that even if all team members have been involved in devising-, and buying into the closure vision, achievement of the site's vision is highly dependent on the specific mine manager – the more involved and focused the mine manager, the higher the level of side-wide awareness and integration.
11. The post-mining vision appears to be an underlying driver for most of the companies in setting the basic direction of rehabilitation measures, regardless of the level of detail of the EMP vision commitments. On sites with generic EMP vision commitments, rehabilitation measures can easily be aligned to the vision as it lacks specific details. For those sites with dedicated post-mining rehabilitation designs, the rehabilitation measures are more accurately aligned to the required final vision outcome.

Step 3: Land's capabilities (questions 12 and 13)

The cumulative responses to the Step 3: land's capabilities' questions are summarised in Table 13.

Table 13: Cumulative responses to the Step 3: land's capabilities' questions

No.	Question	Interviewee response (percentage %)		
		Yes	Maybe	No
12	Current land capabilities will achieve EMP commitments	0%	40%	60%
13	Rehabilitated areas will achieve any type of functional post-mining land use/s	40%	60%	0%

12. None of the interviewees were certain that current mine land capabilities will achieve EMP post-mining land use commitments. For those mines with generic EMP vision commitments, achievement of functional land capabilities seems unlikely. Although some mines are showing a positive trajectory towards rehabilitation success, this appears to be highly dependent on the person responsible for the actual in-field rehabilitation and the intensity of the focus. Without continual assessment and refinement to managing the rehabilitated land, degradation of the areas occurs quickly and land capabilities quickly deteriorated from what was originally planned. Interestingly, it was also highlighted that rehabilitation – and more specifically failure of these areas resulting in, for example, increased water ingress through back-filled spoils or on-surface soil erosion, is seen as a site risk. Hence, it is the management and

reduction of the actual site risk that becomes a focus, more than a driver for functional land capabilities.

13. Many rehabilitated sites do not receive the care-and-maintenance required up and over the 'standard' 2 – 5-year monitoring period timeframe. (This is a general time period stipulated in more EMPs for site rehabilitation monitoring). This results in erosion, loss of topsoil and often poor vegetation establishment. Significant work would be required to improve the functionality of these systems. However, on those sites with dedicated post-mining land zoning and mapping, as well as in areas where specific post-mining land use projects have been implemented (mostly farming or biodiversity-related), there appears to be some land use successes being achieved. Hence, achievement of some type of land functionality may be possible; this will just require notable personnel-, time- and financial resources, as well as implementation of dedicated monitoring programmes.

Step 4: Rehabilitation alignment (questions 14 to 16)

The cumulative responses to the Step 4: Rehabilitation alignment questions are summarised in Table 13.

Table 14: Cumulative responses to the Step 4: Rehabilitation alignment questions

No.	Question	Interviewee response (percentage %)		
		Yes	Maybe	No
14	Rehabilitated areas would require re-rehabilitation	80%	0%	20%
15	Mine-wide awareness of capital required to 're-rehabilitate'	20%	20%	60%
16	Engagement with regulators on need to redefined EMP rehabilitation commitments	40%	40%	20%

14. All interviewees agreed that areas having already been rehabilitated would, in all likelihood, need to be 're-rehabilitated'. This is in specific reference to achievement of the predefined post-mining land uses/, which are predominantly grazing or agriculture. As most rehabilitated areas are not actively managed, regression in functionality occurs over time. In most cases, it could take many years to improve the rehabilitated land capabilities to any form of function above wilderness or low-intensity grazing. In addition, it was noted that it may not necessarily be the level of rehabilitation that is poor, but more the effect of mining on interlinked biophysical processes, such as water availability to planted vegetation. Opencast coal mining results in a lowered groundwater table that could take many years to re-establish. Hence, this lowered water table hinders irrigation capabilities – both from a water quality and quantity perspective. This highlights the complexities around rehabilitation, emphasizing the need for focused rehabilitation measures that have considered as many physical, biophysical and socio-economic aspects as possible.

15. Although regional teams are aware of rehabilitation-related costs, on-site teams generally are focused on physical rehabilitation costs, such as those associated with material movement. There appears to be a general lack of awareness of other rehabilitation costs such as maintenance of infrastructures, site security, stakeholder engagement, etc. This results in varying levels of awareness of the actual cost of rehabilitation, and the need to get it right the first time. On mines where a risk-based approach has been incorporated into rehabilitation and closure planning, the associated time and cost implications of having to 're-rehabilitate' are now driving setting of new rehabilitation measures. By refining rehabilitation measures, more accurate costs can be reflected – this appears to be resulting in buy-in from senior management and the subsequent filtering-down of this focus into the mining operations.
16. On many sites it appears that the discussions on re-defining post-mining rehabilitation commitments is taking place in-house, but not with regulators. Although there is some engagement with regulators on operations that are either already decommissioned or nearing decommissioning, for those sites that lack a clear post-mining vision, it is difficult to discuss with- or motivate to regulators the need for alternative land use/s. However, having to compile Closure EMPs as part of the process for applying for a closure certificate, provides an opportunity for operations to refine and/or modify previously committed post-mining land use/s, including the cost-benefits of alternative land use/s. This opportunity also enables active engagement with regulators on these alternative land use/s.

Step 5: Measurement and monitoring (question 17)

The cumulative responses to the Step 5: measurement and monitoring questions are summarised in Table 13.

Table 15: Cumulative responses to the Step 5: measurement and monitoring questions

No.	Question	Interviewee response (percentage %)		
		Yes	Maybe	No
17	Measurement & monitoring is a key component of rehabilitation success determination	20%	40%	40%

17. There appeared to be some uncertainty as to the level and frequency of monitoring and measurement of rehabilitated areas being undertaken across most companies; only two interviewees clearly noted annual and/or every second yearly land capability assessments on rehabilitated land. However, there was general uncertainty as to exact areas being monitoring, sampling methods used, whether suggested corrective action was being implemented, and the effect thereof. All interviewees agreed that monitoring was not being undertaken frequently enough. Where available, limited

cumulative data is being assessed resulting in uncertain trajectories of rehabilitation success.

Framework structure (questions 18 to 20)

The cumulative responses to the framework structure questions are summarised in Table 16.

Table 16: Cumulative responses to framework structure questions

No.	Question	Interviewee response		
		Yes	Maybe	No
18	Framework structure & flow makes sense	100%	0%	0%
19	Layout & content comprehensive to guide planning thinking	100%	0%	0%
20	Inclusion of this framework would improve way rehabilitation measures are devised	100%	0%	0%

When assessing the structure, layout and function of the preliminary post-mining land use optimisation framework, there was 100% consensus by all of the interviewees on the following:

18. The step-by-step way the framework has been compiled is logical, and makes sense. Each step has a clear context supported by a defined heading, and the framework appears to comprehensively captures all aspects of the post-mining land use planning domain.
19. It was noted by two interviewees that the use of numbers for each step could be perceived as a form of prioritisation, especially within the mining community. However, this was not deemed imperative to amend, provided an accompanying explanation of this 'non-prioritisation' was included.
20. The framework is detailed, yet simple enough to be able to give to any mine planning team member, regardless of their background and/or job-specific focus areas, guidance on the key aspects of post-mining land use planning.
21. All the interviewees indicated that the framework encourages and supports detailed thinking around the importance of using the post-mining landscape as a guide for setting rehabilitation measures. There was also consensus that such a decision-support framework could add value to improve the way rehabilitation measures – for both brownfield and greenfield sites, could be devised.

4.4 Conclusion

4.4.1 Summary of key industry interview perspectives

Based on the responses received during the industry interviews, the following aspects summarise the gauged industry perspectives on the preliminary framework:

- Undertaking such upfront land use planning provides an opportunity to optimise mine planning and operations during the active life of the mine for efficient resource extraction and post-mining land use; (for example reduction of double handling for waste materials and topsoil and reduced areas of land disturbance).
- For mined land rehabilitation to achieve some level of success, holistic thinking is essential, and planning mine closure without post-mining end land use as a major driver of rehabilitation is inexcusable.
- Rehabilitation of mined land is a science not well understood since it integrates many different scientific disciplines which encompass interrelationships over spatial and temporal scales that are often either neglected as part of planning, or just too complicated to correlate. The complexity of land rehabilitation science is exacerbated by the uncertainty of how long-term climatic changes could affect not only implemented individual rehabilitation aspects or activities, but also the functionality of the rehabilitated landscapes over time. This uncertainty requires attention to design rehabilitation criteria that can 'safely fail' instead of the previous and current design philosophy of 'fail safe'. Ultimately, mined land rehabilitation can be much more successful and sustainable if it is recognized as a multi- and interdisciplinary field in both spatial and temporal contexts and receives the necessary attention it requires/deserves.
- Further to the above, inability of currently mining operations to achieve predefined post-mining land use/s is largely dependent on the manner in which rehabilitation is undertaken on-site. In many cases, rehabilitation practices are not sensitive to the specific actions required to implement successful land capabilities that underpin the predefined land use/s (specifically for food production-related land uses such as agriculture). Accordingly, this highlights the importance of defining suitable upfront post-mining land uses, against which rehabilitation practices can be established. This would result in significantly less 're-rehabilitation' of mine sites,
- Monitoring of rehabilitation success is critical as part of setting a post-mining vision and associated rehabilitation measures. Progressive rehabilitation during operations already provides opportunities for testing and improving techniques identified, long before site decommissioning. Accordingly, monitoring of rehabilitation approaches and implemented measures should take place the moment the first portion of mined-out land is rehabilitated.
- Incorporation of such a planning framework in the mine's planning can assist in identification of areas of high risk of (potential or existing) rehabilitation failure. This can then assist in setting priorities for establishment of research projects to refine site knowledge, towards reducing the effect of these risks.
- Above all, it must be acknowledged that mining companies are in the business of mining – inherently, they do not have the skills or core focus required to implement adequate rehabilitation measures. For example, in areas where food security is a regional land use

driver, agronomic principles should be implemented by an agriculturally-trained practitioner, for best rehabilitation results. This highlights the need for rehabilitation to be undertaken by a dedicated rehabilitation officer who has training and experience in both the scientific and practical aspects of land rehabilitation.

4.4.2 Final post-mining land use optimisation framework

Assimilation of the industry perspective on this study's preliminary framework helped to determine the applicability of the framework's structure and content. Although there was some discussion around the numbering of steps in the framework, much of the preliminary framework's structure and content was perceived as being adequate for its purpose. The main comments were term-related, specifically pertaining to *rehabilitation* and *re-rehabilitate*.

The use of the word 'rehabilitation' (*transformation of land from its original condition, (such as through mining), to a new and beneficial condition* (Dale *et al.*, 2000)), was queried by most interviewees. Although it was agreed that this was the term generally used within the South African mining context, it was unanimously noted that 'reclamation' ("*process of converting derelict land to usable land and may include engineering as well as ecological solutions. Restoration and rehabilitation are both aspects of reclamation*" (Post-Mining Alliance, 2015)), would be a more suitable term. However, it was only deemed necessary to amend the heading to the 'reclaimed' landscape instead of the 'rehabilitated' landscape; for consistency with current legislation, the rest of the framework could continue to refer to 'rehabilitation'. Concurrently, the term 're-rehabilitate' was perceived as being unclear. This has subsequently been changed to *corrective action* in Step 4.2.

Although the framework has a strong post-mining land use focus, the interviews with the identified industry role players opened-up discussions on varying aspects of site rehabilitation – post-mining landform designs, opencast- versus underground mining rehabilitation needs, resource allocations, importance of long-term monitoring and trend analysis, risk-based approaches, etc. Most interviewees commented on how the discussion made them think about varying aspects of rehabilitation, many being underpinned by the post-mining land use/s. This author believes that this is ultimately the goal of any planning framework – the need to raise awareness on the subject matter, by asking the right questions, towards being able to identify gaps in knowledge that could improve the site's eventual outcomes.

Figure 24 provides the final post-mining land use framework, devised as part of this study, and taking cognizance of the refinements above.

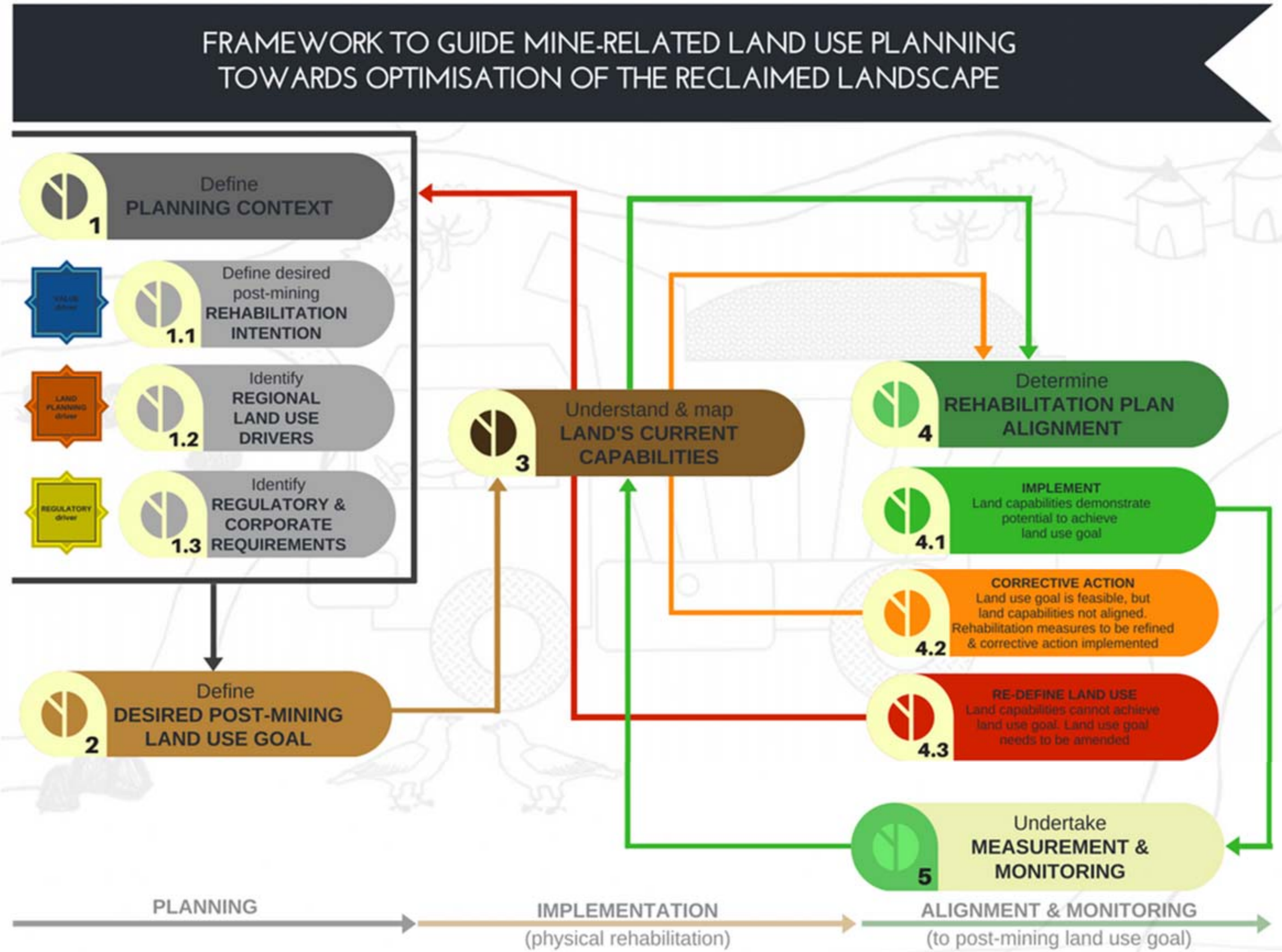

Figure 24: Final post-mining land use optimisation framework

CHAPTER 5: CONCLUSION

This study was undertaken to determine if, by understanding the land use requirements of the post-mining landscape, the mine's ability to achieve its rehabilitation goals will improve.

Review of available literature indicated that a plethora of international and country-specific regulatory and corporate guidelines, and planning tools have been produced, often providing detailed step-wise approaches to the key aspects needing to be included as part of mine rehabilitation and closure planning. Historically and, for the most part, currently, the legislation and guidelines specifically require that land be returned to a condition as close as possible to the pre-mining situation.

The literature also indicated that pre- and post-mining landscapes often differ dramatically from each other, with surface mining involving a twofold change in land use - from a pre-mining landscape to a mining landscape, and then from a mining landscape to a post-mining landscape. Unfortunately, pre-mining land use/s, which are still the predominant post-mining land use goal, are technically, practically and financially challenging to recreate due to the significant alternation of the pre-mining landscape by the mining process.

However, it appears that defining viable post-mining land uses as a core component of setting rehabilitation goals has come to the forefront of countries in which large portions of the mining industries are reaching the end of their life-cycles. This appears to be driven by the scientific understanding that being able to prove achievement of successful rehabilitation is dependent on a well thought-through post-mining land use/s, that have a functional role in a rehabilitated landscape.

The need for a wider regional planning approach as opposed to site-specific plans has also gained momentum. From a sustainability perspective, such regional plans would assist not only in aligning economic contributions in a region, but also to prevent irreparable environmental and social damage to the region. At a local level, site-specific land planning could be short-sighted and incomplete if not considered as part of the larger landscape. Cross-boundary/neighbour land integration could offer more rehabilitation opportunities purely based on increased geographic footprint areas for ecological habitat/productive land/urban development enhancement. There could also be a pooling of human and financial resources to both fund rehabilitation of disturbed areas as well as manage implemented land uses over time.

Unfortunately, post-mining land use planning epitomises a 'wicked problem' in that it requires consideration and integration of ecological, social, political, cultural and economic drivers which operate over varying temporal and spatial scales. These drivers need to be aligned with the expectations of numerous stakeholders that either impact on the landscape and/or will be affected by its long-term land capability and use. These expectations are often defined by corporate-specific core values that vary between achieving minimum regulatory requirements (compliance) versus those that aim to achieve international best practice (stewardship). Further complications arise with the plethora of scientific disciplines required to define and continually asses the post-mining rehabilitation success trajectory.

It is noted that no matter the detail or forward-thinking approach adopted by local legislation, successful implementation and achievement of stipulated rehabilitation measures is often a function of regulator involvement and enforcement. Yet, global experience and research indicates that in many cases there is "inadequate guidance for companies on how to develop clear rehabilitation goals, plans and monitoring systems. Without clarity on rehabilitation requirements, it is difficult for companies to be confident that their rehabilitation will be deemed 'successful' by regulators" (Glenn *et al*, 2014). Hence, as long as regulatory authorities are reluctant to grant closure certificates, mining companies mining will continue to select post-mining land uses that offer the greatest likelihood of relinquishment, rather than the most sustainable land use.

The ***post-mining land use optimisation framework*** developed as part of this research underpins the need for examining site-specific decisions within the regional land planning context as well as in relation to the social, economic, and political perspectives within the mine's localised planning domain. It emphasizes that the spatial and temporal planning and implementation of rehabilitation and land use-related activities remain continually changing throughout the mining life cycle. This implies that amendments, refinements or corrective action should be an integral aspect of this planning, improving the trajectory towards success as new site knowledge and learnings becomes available. Rehabilitation activities should be implemented as soon as site disturbance (construction) starts and maintained throughout the operational and decommissioning periods. More importantly, these activities remain even more pertinent to the monitoring and maintenance period, during which successful implementation of the pre-defined land use/s can be demonstrated.

Rehabilitation-, land use and mine closure plans are hence 'living', changing tools, aligned towards a common goal – defining a resilient post-mining landscape that will, ultimately, enable harnessing the altered landscapes' new characteristics to optimise services to post-mining communities that either provides similar resourcing needs from the land, or alternative resources that contribute to the long-term viability of the area.

In conclusion, this study has indicated that the compilation of a suitable rehabilitation plan in the upfront mine planning stages of an operation, incorporating defined end land use objectives, is imperative in identification of appropriate biophysical and socio-economic post-mining goals that could be agreed with regulators. This would greatly assist towards limiting and even mitigating mining-related environmental impacts in a timely manner. It could also help in reinstating practical, defensible post-mining land uses, developing local skills, creating job opportunities and enhancing long-term post-mining sustainable livelihoods. This could further result in counteraction of the effects of possible future political and/or environmental debates that could ultimately end in unplanned closure of an operation.

Ultimately, understanding the spatial and temporal planning domain in which the mine is operating, and incorporating the associated longer-term regional human land use-related needs into rehabilitation planning can improve a mine's ability to achieve its rehabilitation goals.

As so aptly described by Comp (2013), "*if we design to engage the public; if we interpret these [mine] sites in ways that allow understanding; if we admit that good science is always necessary but sometimes not sufficient; if we use public history to inform the future, we create the opportunity for much broader public participation in reclamation issues. We may even do some small things to help rekindle a reason for pride in coal*".

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APPENDIX A:

Industry perspective questionnaires (Mines A, B, C, D & E)

MINE A

Date of discussion	27 April 2017
Name of mining company	Mine A
Years of experience	21
Focus of experience	Rehabilitation, land management

Question		Response			
		1 YES	2 MAYBE	3 NO	Comment
Framework content					
Step 1					
1	Does your company have a dedicated rehabilitation strategy that guides mine-wide rehabilitation planning?	1	0	0	Anglo American Mine Closure Toolbox (Toolbox) - although it is used for overarching mine closure planning, dedicated rehabilitation (closure) measures (criteria) are conceptualised as part of a dedicated team-wide workshop. When the environmental risk assessment is undertaken as part of the Toolbox, adequacy of rehabilitation measures is assessed in terms of their effectiveness in relevant risk mitigation. Each mine site has a dedicated closure plan compiled as part of this approach.
2	Is defining a post-mining land use incorporated as a key component in company rehabilitation planning?	1	0	0	The Toolbox enables identification of a post-mining land use. However, this is usually determined by the pre-mining land use, and ability of company to emulate approximate pre-mining land capability percentages. For example, if the pre-mining capability was 80% arable and 20% grazing, a similar post-mining land ratio would be aimed for. No dedicated upfront land use planning to identify regional and/or site-specific post-mining land use needs.
3	Is there a team member dedicated to rehabilitation planning ('rehabilitation champion') on each mine?	1	0	0	Rehabilitation is guided by the Regional Office. However, on some sites nearing decommissioning, there is a dedicated rehabilitation and/or land manager (in addition to the environmental manager) responsible for implementation of rehabilitation measures, corrective action and monitoring. Where there is no dedicated rehabilitation manager, the environmental manager is responsible for rehabilitation-related aspects.

4	Does the company have a clearly defined rehabilitation intention against which site planning can take place?	0	1	0	Not in the definition of the term, for this framework. However, there is an underlying acknowledge in the company that site rehabilitation needs to comply with local legislation, and be financially viable (cost-driven). The company's core responsibility is one of mining. Hence, the regulatory driver is perceived to be of utmost importance, followed by production-related financial gain to the benefit of company shareholders. However, it is noted that the way in which rehabilitation is undertaken on-site is often highly dependent on the personal drivers of the specific mine manager or rehabilitation team member - where rehabilitation is a passion within the specific team, the 'rehabilitation intention' has a definite 'do the right thing' component.
5	Have the regional land use needs in which the mines are operating, as defined in this framework, been identified and incorporated in rehabilitation planning?	0	0	1	Not as defined in this framework. Most rehabilitation and closure planning is site-specific. However, for aspects such as long-term water-make - which is a critical Mpumalanga Province challenge, joint ventures have been undertaken together with other regional mining houses to establish a collaborative water treatment plant. This plant accepts water from numerous operations, with resultant potable water utilised by local municipalities.
6	Are the mines getting support and guidance from regulators in defining post-mining land and associated rehabilitation needs?	0	0	1	Significant, constant change in regulatory personnel, which makes it difficult to establish relationships that could guide such planning. Perception that even the regulators are not aware of 'regional land use drivers'. Hence the prominent regulatory driver. There are also varying regulatory role players in rehabilitation, with varying levels of understanding of complex rehabilitation aspects and varying levels of regulatory input. In the absence of strong regulatory guidance and legislative enforcement, aspects such as rehabilitation would benefit from being industry-driven. As industry creates the mining-related environmental challenges, they are in the best position to contextualise them, and identify the most suitable ways to address them. Industry could be supported by academic institutes to ensure implementation and monitoring of scientifically-sound measures. Solutions identified from such an industry-academia relationship could be used to motivate to regulators the most suitable rehabilitation and post-mining land use needs.

7	In your opinion, do you agree that devising a suitable post-mining land use should be a key component of rehabilitation planning?	1	0	0	Some form of land functionality is required to ensure a post-mining land use. Without a clear vision as to what needs to be achieved, it is difficult to ensure rehabilitation measures will be successful.
Step 2					
8	Does each site have a clearly defined post-mining (land use, rehabilitation or closure) vision?	1	0	0	A stage in the Toolbox approach is to conceptualise a closure vision. This is also undertaken in a team workshop.
9	If there is a post-mining vision, has this been devised by a transdisciplinary team?	1	0	0	See response to Question 8
10	Is there an awareness within the mine teams responsible for rehabilitation implementation (mine manager, planners, environmental personnel, contractors, etc.) of the site's post-mining vision?	1	0	0	See response to Question 8. It is noted that
11	Have rehabilitation measures been specifically defined to achieve this vision?	1	0	0	See response to Question 1. In addition, each mine has a dedicated post-mining rehabilitation landform design against which concurrent rehabilitation is undertaken. The rehabilitation measures are aligned to achievement of this post-mining topography, which must be stable and non-polluting (legislative needs).
Step 3					
12	In your view, will the current land capabilities of operational mines be able to achieve authorised EMP land use commitments?	0	0	1	Rehabilitated areas and, more specifically, failure of these areas, is seen a risk to the sites - reduced land capabilities, increased erosion, water ingress, etc. Hence, focus is on creating those stable, non-polluting systems, more than functional land capabilities.
13	Would areas that have already been rehabilitated be able to support any type of functional post-mining land use/s, regardless of EMP land use commitments?	0	1	0	On those sites where the rehabilitation team member has implemented specific projects (mainly farming-related), alternative land uses are being achieved. Although they take up significant personnel, time and financial resources, they demonstrate how successful well-planned, monitored programmes can be.
Step 4					
14	Is it foreseen that areas that have already been rehabilitated would require refinement of existing rehabilitation measures and/or corrective action to achieve current EMP land use commitments?	1	0	0	Yes, regression of the areas occurs over time, this is mainly because the areas is not actively managed in terms of a dedicated land use. Non-compliance to the EMPR due to technical problems such as topsoil shortages will need to be addressed with the regulator and a offset system will need to be devised to compensate for capability losses
15	Is there a general awareness at the mines of the cost, time and human capital required to 're-rehabilitate' areas, should this be required?	0	0	1	Regional awareness is there, but not necessarily at the mines.

16	If the general awareness noted above is present, has the company started engaging with in-company decision-makers and/or regulators on the need to re-define rehabilitation commitments?	0	1	0	There is some engagement with regulators on some sites nearing decommissioning, or already in partially decommissioned. This engagement is around what alternative land uses could be considered into the future.
Step 5					
17	Is measurement and monitoring a key component of rehabilitation success determination?	0	0	1	There are no post-rehabilitation land capability assessments undertaken to determine effectiveness of placed soils, and implementation of corrective action if required. Measurement and monitoring is undertaken in rehabilitated areas, but not necessarily at the frequency it should.
Framework structure					
18	Does the flow (step-wise approach) of the framework make sense?	1	0	0	It does, if priority is not intended this should just be highlighted
19	Is the layout and content comprehensive enough to guide planning thinking at the mines, across all team levels, yet simple enough not to be tedious?	1	0	0	Yes
20	Would inclusion of this type of framework into your company's mine planning - greenfields or brownfields, improve the manner in which rehabilitation measures can be devised?	1	0	0	This would be helpful for greenfields operations, but could be more difficult to implement in brownfields where the luxury of being proactive in rehabilitation is more challenging.

Further comments	
	Even if the site has a good rehabilitation plan, if the mine plan changes, it's not always possible to alter the rehabilitation measures.

MINE B

Date of discussion	03 May 2017
Name of mining company	Mine B
Years of experience	18 years
Focus of experience	Rehabilitation, closure, post-mining land management

	Question	**Response**			
		1 YES	**2 MAYBE**	**3 NO**	**Comment**
Framework content					
Step 1					
1	Does your company have a dedicated rehabilitation strategy that guides mine-wide rehabilitation planning?	1	0	0	The company realises that mining is a finite land use. Also, that the social pressure to reinstate functional post-mining landscapes is so high that a 'walk-away' closure scenario is not an option for Exxaro. With this in mind, the company has recently (2016) implemented a 5-year plan for creating alternative land uses on mine sites, focussing on water, food and energy as land use drivers. This has resulted in creation of a technology and innovation 'Business of Tomorrow' Division responsible for identifying ways in which land can be functionally used (outside the mining domain) into the future. The goal of this plan is to be able to either sell-off the rehabilitated mined land that will have a defined land function to a third party, or maintain shares as part of the new land use. Hence, there is a dedicated rehabilitation strategy - its focus is company-wide, and rehabilitation of specific sites is considered an integral part of achieving this 5-year plan.
2	Is defining a post-mining land use incorporated as a key component in company rehabilitation planning?	1	0	0	See response to Question 1.
3	Is there a team member dedicated to rehabilitation planning ('rehabilitation champion') on each mine?	1	0	0	Often this is the site environmental person. However, many of the sites nearing decommissioning have dedicated rehabilitation champions.
4	Does the company have a clearly defined rehabilitation intention against which site planning can take place?	0	1	0	Although there is no defined rehabilitation intention, the regional Executive Committee (EXCO) are responsible for signing-off on both greenfields and brownfields post-mining land commitments. Alternative land capabilities, exploiting remaining voids and trying to mimic ecological functionality are three focus areas for these land commitments. There is a strong underlying value driver of 'wanting to do the right thing'.

5	Have the regional land use needs in which the mines are operating, as defined in this framework, been identified and incorporated in rehabilitation planning?	1	0	0	As the above-mentioned 5-year plan focuses on alternative land uses, the regional planning needs for those mines nearing decommissioning are investigated. This is to determine possible regional synergies with which the rehabilitated mine sites can be aligned or incorporated into. However, it is noted that it is not so much an assessment of regional land use needs as an assessment of future business-related drivers that could generate viable land use opportunities.
6	Are the mines getting support and guidance from regulators in defining post-mining land and associated rehabilitation needs?	0	0	1	Regulations are world-class, but often the post-mining land functions aspects focus on health & safety more than actual land capabilities. Hence, when on-site, regulators appear more concerned with a site's long-term health & safety needs (void access, fencing, quality of decanting water, etc.) than actually helping guiding viable rehabilitation measures or post-mining land uses.
7	In your opinion, do you agree that devising a suitable post-mining land use should be a key component of rehabilitation planning?	1	0	0	The only way to ensure a rehabilitated mine site has a post-mining function is to ensure that a viable next land use has been identified.
Step 2					
8	Does each site have a clearly defined post-mining (land use, rehabilitation or closure) vision?	1	0	0	Each site has a dedicated final landform design that represents the topography and soil placement of the rehabilitated post-mining landscape. Concurrent rehabilitation is undertaken according to this design, which is aimed at achieving a specific, pre-defined post-mining vision.
9	If there is a post-mining vision, has this been devised by a transdisciplinary team?	1	0	0	Getting buy-in from all team members is considered key. Prior to EXCO signing-off on a site's post-mining vision, it has been workshopped with the mine team.
10	Is there an awareness within the mine teams responsible for rehabilitation implementation (mine manager, planners, environmental personnel, contractors, etc.) of the site's post-mining vision?	1	0	0	As the company's EXCO is responsible for signing-off on both greenfields and brownfields post-mining land commitment, it is expected that all mine teams are aligned to the agreed-on post-mining vision. However, it is noted that achievement of the site's vision is highly dependent on the specific mine manager - the more involved and focused the mine manager, the higher the level of site-wide awareness and integration.
11	Have rehabilitation measures been specifically defined to achieve this vision?	1	0	0	Rehabilitation measures are aligned to the final landform design, which is aligned to the vision.
Step 3					
12	In your view, will the current land capabilities of operational mines be able to achieve authorised EMP land use commitments?	0	1	0	In some areas on some mines. It is noted that although implementation of rehabilitation measures is a given focus during mining, actual adaptive land management of rehabilitated areas is not adequate. This can result in degradation of rehabilitated areas,

					and reduced land capabilities to what was originally planned.
13	Would areas that have already been rehabilitated be able to support any type of functional post-mining land use/s, regardless of EMP land use commitments?	1	0	0	All company mining-related areas have been electronically mapped and georeferenced, towards being able to identify areas available for specific post-mining land uses. This mapping includes land ownership, tenure, and rehabilitation status, and indicates varying levels of land functionality, regardless of EMP land use commitments.
Step 4					
14	Is it foreseen that areas that have already been rehabilitated would require refinement of existing rehabilitation measures and/or corrective action to achieve current EMP land use commitments?	1	0	0	Many rehabilitation measures were compiled as part of historical EMPs. These often refer to reinstatement of pre-mining land use/s that are not achievable with current rehabilitation knowledge. However, as the company's rehabilitation strategy has recently focused on alternative post-mining land uses, alignment to EMP-committed land uses is not considered critical.
15	Is there a general awareness at the mines of the cost, time and human capital required to 're-rehabilitate' areas, should this be required?	0	0	1	Miners often only see the physical rehabilitation costs, such as material movement. They are not aware of 'associated' rehabilitation costs such as maintenance of infrastructure (buildings, fences, pipelines, roads, etc.), site security, stakeholder engagement, upskilling/capacity building, etc.
16	If the general awareness noted above is present, has the company started engaging with in-company decision-makers and/or regulators on the need to re-define rehabilitation commitments?	1	0	0	As the company's mines approach decommissioning, attention is placed on compilation of MPRDA-required Closure EMPs. This document is aimed at providing detailed rehabilitation measures for site decommissioning, monitoring and eventual closure. Exxaro is using these EMPs as an opportunity to refine and/or modify previously committed to post-mining land use/s, including dedicated cost-benefit analysis of new land use/s. Regulatory and stakeholder engagement and buy-in is an integral component of these Closure EMPs.
Step 5					
17	Is measurement and monitoring a key component of rehabilitation success determination?	0	1	0	Rehabilitation standards need to be more clear and formal monitoring reports produced.
Framework structure					
18	Does the flow (step-wise approach) of the framework make sense?	1	0	0	Yes
19	Is the layout and content comprehensive enough to guide planning thinking at the mines, across all team levels, yet simple enough not to be tedious?	1	0	0	Step-wise approach encourages thinking at all steps.

20	Would inclusion of this type of framework into your company's mine planning - greenfields or brownfields, improve the manner in which rehabilitation measures can be devised?	1	0	0	Yes

	Further comments
	One site-specific rehabilitation intention is unlikely; more likely to have a suite of intentions across a site. A key driver for successful rehabilitation is to show the financial benefits of implementing concurrent site rehabilitation. This would include showing that: *Rehabilitation undertaken during mining can be undertaken at mining contractor rates, which can be up to 30% less of rehabilitation rates; *Machinery and equipment are already on-site during operations, and hence would not require post-mining site establishment and operational costs; *Concurrent rehabilitation is undertaken at the current year's operational rates; should rehabilitation be undertaken at a time into the future, this would be at annually escalated future rates; *Reduced / minimal double-handling of material as excavated/removed burden can be immediately replaced at rehabilitation location; and *Reduced final rehabilitation volumes needing to be covered post-mining, when financial resources are no longer available. Ultimately, concurrent rehabilitation is not just about getting site closure, but about reducing site risks. Therefore, by prioritising mitigation of a site's risks, rehabilitation measures can be prioritised and appropriately defined. Simplicity in rehabilitation planning is also key. Rehabilitation measures, resources and budget should be linked to the mine plan in a simple map format that can be easily tracked and refined. Establishment of short-term goals also allows for focussed attention and implementation of specific corrective action/refinement needs. Small successes motivate teams to try achieve more small successes, which ultimately lead to site-wide rehabilitation success.

MINE C

Date of discussion	05 May 2017
Name of mining company	Mine C
Years of experience	14 years
Focus of experience	Environmental, rehabilitation, closure

	Question	**Response**			
		1 YES	**2 MAYBE**	**3 NO**	**Comment**
Framework content					
Step 1					
1	Does your company have a dedicated rehabilitation strategy that guides mine-wide rehabilitation planning?	1	0	0	In-house 'rehabilitation strategy' that all mines are expected to comply with.
2	Is defining a post-mining land use incorporated as a key component in company rehabilitation planning?	1	0	0	However, post-mining land use is determined by the pre-mining land use, and ability of company to emulate approximate pre-mining land capability percentages. For example, if the pre-mining capability was 80% arable and 20% grazing, a similar post-mining land ratio would be aimed for. No dedicated upfront land use planning to identify regional and/or site-specific post-mining land use needs.
3	Is there a team member dedicated to rehabilitation planning ('rehabilitation champion') on each mine?	0	0	1	The individual mine's environmental manager is responsible for rehabilitation-related aspects.
4	Does the company have a clearly defined rehabilitation intention against which site planning can take place?	1	0	0	Within the past two years, the Glencore Coal CEO has implied that the 'corporate mandate' (intention) for rehabilitation should be post-mining land quality and not purely the quantity of hectares rehabilitated. The company is aiming to focus towards improved land functionality that can be maintained over time. In the past, the company was renowned for its 'do the right thing' value driver. For various reasons, this thinking changed a few years back, with the focus becoming one of regulatory compliance. However, more recently, as per the above-stated corporate mandate, there appears to be an overarching re-focus in rehabilitation planning that is again guided by 'doing the right thing'.
5	Have the regional land use needs in which the mines are operating, as defined in this framework, been identified and incorporated in rehabilitation planning?	0	0	1	Although there is a company-wide rehabilitation intention, alignment and implementation depends on the characteristics of the site-specific pre-mining landscape. For example, if Red Data species are evident, this will drive a post-mining ecological rehabilitation focus. This site-specific rehabilitation focus does not take cognisance of regional and/or cross-

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					boundary (of even adjacent Glencore) operations.
6	Are the mines getting support and guidance from regulators in defining post-mining land and associated rehabilitation needs?	0	0	1	Even on sites where interactions with regulators are taking place on a frequent basis, this is more from an environmental authorisation compliance perspective. No guidance, support and/or suggestions are offered, towards improving site management.
7	In your opinion, do you agree that devising a suitable post-mining land use should be a key component of rehabilitation planning?	1	0	0	Yes, definitely. When planning is done with a clear end goal the outcome is usually a better land use product.
Step 2					
8	Does each site have a clearly defined post-mining (land use, rehabilitation or closure) vision?	1	0	0	Incorporated as part the EMP and/or closure plan, where one exists for the site.
9	If there is a post-mining vision, has this been devised by a transdisciplinary team?	0	0	1	This vision is usually devised by the consultant who compiled the EMP. Although there is sign-off of this vision by the mining team, no/limited group consultation or workshopping of the vision takes place.
10	Is there an awareness within the mine teams responsible for rehabilitation implementation (mine manager, planners, environmental personnel, contractors, etc.) of the site's post-mining vision?	0	1	0	Teams directly responsible for environmental matters are aware of the post-mining vision, as it's part of the EMP. However, there is a lack of alignment between environmental and mining teams on the effort required to achieve this vision. Post-mining land capabilities are seen to be complete once initial site rehabilitation has taken place, with limited focus on corrective action or whether or not land functionality is adequate for achievement of the committed vision.
11	Have rehabilitation measures been specifically defined to achieve this vision?	1	0	0	Rehabilitation measures are tailored to the post-mining vision.
Step 3					
12	In your view, will the current land capabilities of operational mines be able to achieve authorised EMP land use commitments?	0	0	1	No. As mentioned above, often the manner in which rehabilitation is assessed, reviewed and monitored, with implementation of correction action if required is ad hoc and infrequent.
13	Would areas that have already been rehabilitated be able to support any type of functional post-mining land use/s, regardless of EMP land use commitments?	0	1	0	However, in most cases, it would take many years to improve rehabilitated land capabilities to any form of function above wilderness or low-intensity grazing. Hence, significant time and financial resources are still required to achieve the company goal of 'improved land functionality that can be maintained over time'.
Step 4					

14	Is it foreseen that areas that have already been rehabilitated would require refinement of existing rehabilitation measures and/or corrective action to achieve current EMP land use commitments?	1	0	0	See response to Question 13.
15	Is there a general awareness at the mines of the cost, time and human capital required to 're-rehabilitate' areas, should this be required?	0	0	1	Rehabilitation-related corrective action is undertaken on an ad hoc basis, as the site-specific need arises.
16	If the general awareness noted above is present, has the company started engaging with in-company decision-makers and/or regulators on the need to re-define rehabilitation commitments?	0	0	1	It was acknowledged that without having a clear understanding of the current land's capabilities (Step 3), it would be difficult to discuss with- or motivate to regulators the need for an alternative post-mining land use to that committed to in the EMP.
Step 5					
17	Is measurement and monitoring a key component of rehabilitation success determination?	0	1	0	Monitoring of rehabilitated areas is undertaken in the form of annual land capability assessments. However, identified corrective action is not always implemented.
Framework structure					
18	Does the flow (step-wise approach) of the framework make sense?	1	0	0	Seamless and easy to read.
19	Is the layout and content comprehensive enough to guide planning thinking at the mines, across all team levels, yet simple enough not to be tedious?	1	0	0	Incorporates fundamental aspects of rehabilitation planning.
20	Would inclusion of this type of framework into your company's mine planning - greenfields or brownfields, improve the manner in which rehabilitation measures can be devised?	1	0	0	Any such tool will be welcome in the industry. If it facilitates easier decision making and is user-friendly it will be used.

Further comments	
	It is foreseen that there will be 'pockets of excellence' across each site, where rehabilitation outcomes can be better than in other areas (such as long-term functionality of rehabilitated waste rock dumps compared to reclaimed infrastructural footprint areas). Also, for brownfields sites, the rehabilitation intention would be guided by the age of the site. Historically active sites, or those having been operated over a long period of time were authorised under varying (and often less stringent) environmental legislative requirements. Hence, some sites exhibit historical environmental impacts resulting in no possible way to achieve a similar rehabilitation intention as those sites operating under more recent legislative requirements. This will result in a mosaic of 'rehabilitation intentions' across one site, which may also require off-site environmental offsets.

MINE D

Date of discussion	24 April 2017
Name of mining company	Mine D
Years of experience	42
Focus of experience	Business sustainability; mine closure

	Question	**Response**			
		1 YES	**2 MAYBE**	**3 NO**	**Comment**
Framework content					
Step 1					
1	Does your company have a dedicated rehabilitation strategy that guides mine-wide rehabilitation planning?	0	0	1	No specific rehabilitation strategy. However, Sasol has specifically identified that the EMP, being the legislative-driven document, should play this role for each mine, and hence believes there is no need for such a strategy. In addition, it is note that most of the company's operation are underground mines, For these operations, there is a strategy to address surface subsidence resulting from pillar instability/failure, which is a key rehabilitation driver.
2	Is defining a post-mining land use incorporated as a key component in company rehabilitation planning?	0	1	0	Risk management drives rehabilitation planning. Due to the nature of mining, there are often risks of higher consequence (pillar instability and associated surface subsidence; water quality feeding local catchments; erosion and sedimentation, etc.) that need to be addressed rather than post-mining land use. However, the impact of inadequate post-mining land capabilities as well as loss of land us functionality is becoming more evident, and it is foreseen that these risks will start driving more focussed upfront post-mining land use planning as part of long-term successful rehabilitation establishment.
3	Is there a team member dedicated to rehabilitation planning ('rehabilitation champion') on each mine?	0	0	1	Rehabilitation falls under the responsibility of environmental managers.
4	Does the company have a clearly defined rehabilitation intention against which site planning can take place?	0	0	1	Not in the definition of the term for this framework. There will always be a 'need' to stay in business, and so any rehabilitation intention needs to be financially feasible to the company. However, provision of a Mining Right comes with a responsibility - as a mining company, the right is given to mine-out / impact the land. Concurrently, the responsibility to implement EMP measures towards achieving functional post-mining landscapes is also expected as part of the Authorisation. Hence, it is expected that compliance with authorised conditions, that have an underlying value driver, will occur.

5	Have the regional land use needs in which the mines are operating, as defined in this framework, been identified and incorporated in rehabilitation planning?	0	0	1	Most mine closure planning to date has been site-specific. This is the same for EMP compilation, many of which have been compiled by sub-consultants who may not have had good insight into site-specific rehabilitation needs. Most of the existing EMPs are generic with regard to land use/rehabilitation measures, with post-mining land capabilities of grazing being a standard requirement.
6	Are the mines getting support and guidance from regulators in defining post-mining land and associated rehabilitation needs?	0	0	1	In South Africa, EMPs are compiled at the discretion of the mining houses. This entitles the companies to set their own rehabilitation and land use needs - without dedicated guidance and/or enforcement by regulators, these needs will continue to be sub-standard or unobtainable.
7	In your opinion, do you agree that devising a suitable post-mining land use should be a key component of rehabilitation planning?	1	0	0	The only way to ensure a rehabilitated mine site has a post-mining function is to ensure that a viable next land use has been identified.
Step 2					
8	Does each site have a clearly defined post-mining (land use, rehabilitation or closure) vision?	1	0	0	The closure visions are generally generic and lack detail. This can be associated with the long-term nature of mining contracts - as many mining rights are for periods 30 years+, there is a lack of accountability from on-site managers to have to do the right thing from the start.
9	If there is a post-mining vision, has this been devised by a transdisciplinary team?	0	0	1	Most EMPs have been historically compiled by external consultants. Although sign-off by the mine on content is required, this does not mean concepts such as post-mining vision was workshopped with a team.
10	Is there an awareness within the mine teams responsible for rehabilitation implementation (mine manager, planners, environmental personnel, contractors, etc.) of the site's post-mining vision?	0	0	1	See response for Question 9.
11	Have rehabilitation measures been specifically defined to achieve this vision?	0	1	0	As post-mining visions are often very generic, rehabilitation measures can be aligned very easily to this vision, to varying levels of detail. However, more recently, as risk has become a rehabilitation planning driver, rehabilitation measures are being tailored to reducing these prioritised site risks.
Step 3					
12	In your view, will the current land capabilities of operational mines be able to achieve authorised EMP land use commitments?	0	1	0	As many of the sites are underground mines, provided there is no significant surface subsidence or sinkhole formation, land capability should be largely functional. Many of the surfaces within the mining rights are leased to- or owned by farmers who work the land, in areas not directly affected by mining. For the few opencast operations, it is unlikely that land use commitments (also grazing) will be achieved without attention to at least issues such as erosion mitigation, water management and vegetation management.

13	Would areas that have already been rehabilitated be able to support any type of functional post-mining land use/s, regardless of EMP land use commitments?	0	1	0	As mentioned in Question 12, provided the land was not left fallow during operations (which is not the case for underground operations), functional land capabilities in areas not directly affected my mining-related infrastructure should be achievable. In infrastructure-related areas (processing plants, roads, waste rocks dumps, etc.), EMP commitments are to mainly achieve grazing land capabilities - in underground operations, these could support alternative land use/s, but in opencast operations, effort will be required to create some form of production-related land use/s.
Step 4					
14	Is it foreseen that areas that have already been rehabilitated would require refinement of existing rehabilitation measures and/or corrective action to achieve current EMP land use commitments?	1	0	0	Many rehabilitated sites have, over time, not received the care-and-maintenance they require. This has resulted in increased erosion, loss of topsoil and often poor vegetation establishment. Significant work would be required to improve the functionality of these systems.
15	Is there a general awareness at the mines of the cost, time and human capital required to 're-rehabilitate' areas, should this be required?	0	1	0	Using a risk approach has greatly focused rehabilitation-related site challenges. This has resulted in a change of thinking in regional offices, which is filtering down to individual sites. Through risk identification, rehabilitation measures are being refined. By refining rehabilitation measures, more accurate costs are being reflected, and this is demanding a new focus from senior management.
16	If the general awareness noted above is present, has the company started engaging with in-company decision-makers and/or regulators on the need to re-define rehabilitation commitments?	1	0	0	Aligned to the above, as some sites are applying for closure, rehabilitation-related discussions are being held with regulators. These discussions also highlight that there is money available in existing rehabilitation funds - should regulators make this money available to the companies, it can be spent on implementation of refined, agreed-on measures, whilst the mining company is still around. With improved rehabilitation comes improved land functionality, and increased opportunities to generate income from rehabilitated areas. This income can then be used to fund new rehabilitation. Alternative, these funds could be used to mine-out remaining reserves in brownfields' operations - upfront post-mining land planning can then be refined with current knowledge, improving the chance of successful site-side rehabilitation.
Step 5					

17	Is measurement and monitoring a key component of rehabilitation success determination?	0	0	1	There are some site-specific procedures in place (to identify and address surface subsidence and sinkholes). However, active maintenance and follow-up of these procedures is uncertain. In many cases, the company will compensate the farmer using the land for income lost due to subsidence/sinkholes. It is noted that it would be more optimal to purchase the affected land from the farmers - this will give the company to alter the title deeds and, at the same time, include possible areas of land use exclusion in the deeds, for future utilisation. This will limit unmitigated access to high-risk areas that cannot be controlled when the land does not belong to the company.
Framework structure					
18	Does the flow (step-wise approach) of the framework make sense?	1	0	0	Simple, easy to follow. 'Optimisation' in the framework title could be reconsidered - has too much of a minerals process-related flavour. And, should 'rehabilitation' not be replaced with 'reclamation'?
19	Is the layout and content comprehensive enough to guide planning thinking at the mines, across all team levels, yet simple enough not to be tedious?	1	0	0	-
20	Would inclusion of this type of framework into your company's mine planning - greenfields or brownfields, improve the manner in which rehabilitation measures can be devised?	1	0	0	Yes.

Further comments	
	Mining companies are in the business of mining, and hence they do not have the rehabilitation focus required for adequate rehabilitation. Rehabilitation should be undertaken by rehabilitation specialists. Until such time that regulations create a 'need' for mining houses to do the right thing (i.e. legislative-driven), rehabilitation will remain a 'want', with limited re-investment of capital into rehabilitation practices.

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MINE E

Date of discussion	24 April 2017
Name of mining company	Mine E
Years of experience	12
Focus of experience	Environmental, rehabilitation, closure

Question		Response			
		1 YES	2 MAYBE	3 NO	Comment
Framework content					
Step 1					
1	Does your company have a dedicated rehabilitation strategy that guides mine-wide rehabilitation planning?	0	0	1	No specific company-wide strategy, but EMPs seen as the vehicle for setting rehabilitation measures. There are also other environmental-related overarching strategies - although these refer to land use, it focuses on land capabilities and not land use as a rehabilitation guidance. Specific Mince Closure team ---
2	Is defining a post-mining land use incorporated as a key component in company rehabilitation planning?	1	0	0	Company land management and rehabilitation guidelines - land use component in each of these.
3	Is there a team member dedicated to rehabilitation planning ('rehabilitation champion') on each mine?	0	0	1	Each mine has an environmental officer who has to track and manage rehabilitation performance. There is a separate reporting structure where there are rehabilitation managers responsible for specific sites and/or areas. But, this is not mine-specific.
4	Does the company have a clearly defined rehabilitation intention against which site planning can take place?	1	0	0	Either legislative requirements, or company standards - the highest thereof.
5	Have the regional land use needs in which the mines are operating, as defined in this framework, been identified and incorporated in rehabilitation planning?	0	0	1	Generally linked back to pre-mining land use.
6	Are the mines getting support and guidance from regulators in defining post-mining land and associated rehabilitation needs?	0	0	1	-
7	In your opinion, do you agree that devising a suitable post-mining land use should be a key component of rehabilitation planning?	1	0	0	-
Step 2					
8	Does each site have a clearly defined post-mining (land use, rehabilitation or closure) vision?	1	0	0	Conceptual engineering designs for each mine, linked to a mine-specific closure plan.
9	If there is a post-mining vision, has this been devised by a transdisciplinary team?	1	0	0	Designs - mine planning, environmental, site and regional teams
10	Is there an awareness within the mine teams responsible for rehabilitation implementation (mine manager, planners, environmental personnel, contractors, etc.) of the site's post-mining vision?	1	0	0	On most sites. When there is a change in personnel on the mines, there usually requires a handover of thoughts, processes and procedures. This includes alignment to post-mining land use vision.
11	Have rehabilitation measures been specifically defined to achieve this vision?	1	0	0	-
Step 3					

12	In your view, will the current land capabilities of operational mines be able to achieve authorised EMP land use commitments?	0	0	1	-
13	Would areas that have already been rehabilitated be able to support any type of functional post-mining land use/s, regardless of EMP land use commitments?	1	0	0	Some very successful grazing and biodiversity functionalities.
Step 4					
14	Is it foreseen that areas that have already been rehabilitated would require refinement of existing rehabilitation measures and/or corrective action to achieve current EMP land use commitments?	0	0	1	Current significant challenge is a lowered water table which hinders irrigation capabilities. Hence, it is not the rehabilitation that is of poor quality; it is the effect of the lack of other aspects that is more of a problem.
15	Is there a general awareness at the mines of the cost, time and human capital required to 're-rehabilitate' areas, should this be required?	1	0	0	Notable effort put into not double-handling
16	If the general awareness noted above is present, has the company started engaging with in-company decision-makers and/or regulators on the need to re-define rehabilitation commitments?	0	1	0	Within the company, but not with regulators. Lack of working relationship with regulators; South African mining challenge
Step 5					
17	Is measurement and monitoring a key component of rehabilitation success determination?	1	0	0	Annual or every second year there is a land capability assessment by an external consultant that tracks rehabilitation according to the desired end land use.
Framework structure					
18	Does the flow (step-wise approach) of the framework make sense?	1	0	0	-
19	Is the layout and content comprehensive enough to guide planning thinking at the mines, across all team levels, yet simple enough not to be tedious?	1	0	0	-
20	Would inclusion of this type of framework into your company's mine planning - greenfields or brownfields, improve the manner in which rehabilitation measures can be devised?	1	0	0	-

Further comments	