

Suggesting landscape as a framework for mine closure of abandoned opencast mines based on understanding global practices, standards and vision

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Abstract

Mine closure practices, through the small history of its existence, have evolved and gained a strong understanding of the profession of landscape architecture (Baida et al. 2014). Standards on mine closure from organisations such as the International Council on Mining and Metals (ICMM) since 2008 and the recent International Organization for Standardization (ISO) guidance book have been updated and revised to follow the Sustainable Development Goals. Future vision on mine closure by the World Bank since 2018 specifies the need for "Achieving a Just Transition for All", with key lessons based on policy-strategy development, people and communities, and land and environmental remediation.

Yet mine closure standards and vision based on landscape as an important framework have not been explored or highlighted, despite vocabulary such as landscape restoration, land reclamation, etc., in use when discussing solutions for mine closure (Ignatyeva et al. 2020) and, specifically, opencast abandoned mine sites that have both a physical and environmental impact, such as altered landscape, unproductive and contaminated land, steep and erodible slopes, abandoned mine waste disposal facilities, changes in surface and subsurface water regimes, subsidence, etc. (Bennett 2016; Peck 2005).

The paper will review mine closure practices from the Global North and South, along with the standards and visions of mine closure through the lens of landscape. The paper will raise questions pertinent to the need of a landscape framework as new knowledge, which will be essential in meeting the vision of a Just Transition.

Keywords: *opencast mines, mine closure, landscape framework, Just Transition*

1 Introduction

Extraction of minerals, through creating alterations in the landscape, is an age-old activity. Open pit mining, one of the more destructive method of extraction, often has poor outcomes due to excavation that is only focused on operational standards of safety and resource extraction, with limited consideration of closure requirements (Jones & Salmon 2012; McKenna 2002b). However, it is key to note that mining is a temporary land use and needs an appropriate closure. Closure practices began in the 1960s–1970s, sometime in between the environmental crisis of the 1960s and the Stockholm Conference of 1972 (Mulvey et al. 2012). Subsequent to the conference, closure practices came under immense scrutiny and became a source of investigation and understanding in the field of mine engineering, economic restructuring, ecological regeneration and socio-economic studies (Atteridge 2019; Haney et al. 2003; McKenna, 2002a; Zipper et al. 2011).

Coal mining has specific characteristics that warrant particular attention (Salmon 2018). When open pit coal mines operate, millions of tonnes of rock need to be moved, resulting in distinct landscape changes. Key features of these changes are spoil piles, rejects and tailings depositories, and final voids where mining occurred immediately prior to closure. The alterations in the landscape can create complex and long-term environmental and social challenges for post-mining land use and rehabilitation (Dentoni & Massacci 2013; Lechner et al. 2017). Mine closure is therefore indeed a spatial problem, wherein, historically, town planners and landscape architects have contributed in recognising the problem and suggesting appropriate solutions. It is because landscape as an approach can be seen as a unique synthesis between the natural and cultural characteristics of a region (Antrop 2000). This synthesis cultivates discussion on socio-ecological relations

and spatial representations, keeping in mind the aesthetics of a place, all which are integral to provide a vision to closure of mines.

Mining is an essential activity to cater to the materialistic demands of the industrialised society, but the process of mining disturbs the environment, ecosystem, the geomorphology of the land, and the community that lives with it (Chaloping-March 2018; Strambo et al. 2019; Zipper et al. 2011). The discipline of landscape science has much to contribute to this evolution of thinking. This paper will attempt to highlight the relevance of landscape science as an important frame of reference for mine closure based on systematic observation in time through three different tracks:

- Global practices: Understanding acts and policy documents from the Global North, including the USA, USSR, Australia, and Canada, based on percentage of mining areas in each country (Maus et al. 2020). Germany is included due to early action on the issue of mine closure. The UK too is highlighted for incorporating the *Minerals Act* under *Town and Country Planning Act*.
- Global standards: Understanding the standards set by organisations such as the International Council on Mining and Metals (ICMM) and the International Organization for Standardization (ISO). This will also look at tool kits formulated by the Asia-Pacific Economic Cooperation (APEC) and the World Bank.
- Global visions: Understanding Sustainable Development Goals by UN-Habitat and Just Transition by World Bank.

The research methodology is exploratory in nature, with an argumentative approach using information based on secondary sources of formative and pioneering literature as evidence. The paper ends with questions related to the relevance of the discipline of landscape in being a major contributor to evolving mine closure practices more sensitively. It will further raise the need for landscape frameworks that can help guide the future trajectories of mine closure.

2 Literature review

2.1 Global practices

From the report by EA Nephew on surface mine and land reclamation practices in Germany, prepared as a guide for mine management in the USA, to the present-day discussions on Just Transition, the narration on mine closure evolved from a myopic vision of land reclamation to a more comprehensive vision incorporating policy/strategy development, people/communities and land/environmental remediation (Nephew 1972; World Bank 2018). This section of the paper will look at policies and acts across the Global North and South with regard to the many liabilities that come with mine closure chronologically. It will also simultaneously note the relevant literature that was published in the field of landscape to comprehend the role that the literature provides in the trajectory of mine closure practices.

2.1.1 Global North

Table 1 attempts to chronologically list the mine closure practices observed in the countries stated in the introduction, alongside key landscape science theory and sustainable thinking and design practices.

Table 1 Practices in the Global North with evolution of landscape thoughts

Year	Country	Practices
1920	Germany	'Ruhr Coal Area Settlement Association' (SVR) was founded in Essen and legally authorised by the State of Prussia. Robert Schmidt, the intellectual father and first director of the Association, devoted his energies to three planning targets, which are still relevant today: putting forward proposals for allocating specific uses to areas throughout the region, setting up an efficient traffic network, and interlinking green spaces (Bottmeyer et al. 2012).
1950	Germany	Reinhold Linger started the first nationwide environmental monitoring focused on the destruction caused by the lignite mines in GDR (Baumert 2020). Through 1958–1990, the landscape designer Otto Rindt played a significant role in recultivation and design of the post-mining landscape for the Lusatian region of GDR (Baumert 2020).
1960	USSR	In 1960, the first major piece of legislation governing the reclamation of mined land in the USSR, 'On the Conservation of Nature in the RSFSR' conservation law, was enacted. Article 2 of the law identifies that lands suitable for agricultural use be rehabilitated after the end of mining activity.
1962	USSR	IV Lazareva published 'Restoration (Recultivation) of Disturbed Territories- Experience of District Planning in Urban Planning Abroad' (Ignatyeva 2020). Through 1963–1977, Kenneth L Schellie, a landscape architect and planner, practised reclamation in the American Midwest for sand and gravel sites. He, along with Anthony M Bauer and C Johnson, published many articles on site planning, rehabilitation and land shaping (Burley & Bauer 2000). In 1966, Town Planning Review featured an article on 'Derelict Land in South Wales' (Thomas 1966).
1966	USSR	LV Motorina published on 'Recultivation of Land Disturbed by Industry' for the Academy of Science (Ignatyeva 2020). In 1968, the Institute of Landscape Architects Journal featured an article on 'The Disposal of Pulverised Fuel Ash' based on the disposal methods, landform and the establishment of vegetation for waste product from a modern coal-fired power station.
1968	USSR	LV Motorina & VA Ovchinnikov published 'Recultivation of Territories Disturbed by Quarries' in the <i>Mine Journal</i> (Ignatyeva 2020) and land law was passed (Bond & Piepenburg 1990; Ignatyeva 2020).
1968	USA	After a mine devastation, an advisory council in West Virginia for public and worker safety was formulated (Curran 1984). In 1969, Ian McHarg's seminal work 'Design with Nature' was published, which paved the way for how planners and architects think about the environment, and how complex spatial data can be used to make policy and design decisions (Palazzo & Hollstein 2019).
1969	Canada	British Columbia was the first province to have legislation on reclamation of major coal and mineral mines.
		In 1972, to restore the interdisciplinary approach of landscape research, a working group was created in the Netherlands called the WLO (Workgroup Land-schapsecologisch Onderzoek).

Year	Country	Practices
1972	Germany	Eisenheim workers quarters went under heritage protection due to the rising culture of valuing the industrial past led by Roland Günter (Baumert 2020).
1972	Germany	Report by EA Nephew on 'Surface Mining and Land Reclamation in Germany' as a reference study for mine management in USA (Nephew 1972).
1973	USSR	OP Kravchenko and AA Mazurov published on 'Recultivation of Land Disturbed by Opencast Mining' in Tsvetmetinformatsiya (Ignatyeva 2020).
1973	USA	A Surface Mining Control bill was introduced.
1974	USA	Report on land 'Rehabilitation Potential for Western Coal Lands' by the National Academy of Sciences.
1975	USSR	LV Motorina and VA Ovchinnikov published on industry and land recultivation (Ignatyeva 2020).
1976	UK	Department of Environment worked on a paper highlighting policies and suggesting measure for reclamation of extensive areas of derelict land. It also suggested preventing further dereliction due to mineral extraction activities.
1977	USA	Surface Mining Control bill became <i>Surface Mining Control and Reclamation Act</i> , overlooking regulation of active coal mines and reclaiming abandoned mine lands.
1978	Australia	The <i>Western Australia Mining Act</i> by the Department of Mines and Petroleum was passed.
In 1980, the International Union of Conservation of Nature published a world conservation strategy that included one of the first references to sustainable development as a global priority.		
1980	Canada	The North West Territories Water Board and the Department of Indian Affairs and Northern Development (INAC) began to include a condition that an abandonment and a restoration plan be prepared and submitted for approval as a requirement of water licences and land leases.
1981	UK	<i>Minerals Act of 1981</i> under <i>Town and Country Planning</i> was introduced. It highlighted the need for mineral planning which aimed at a steady and adequate supply of minerals to meet the demands of society at all times, whilst not exploiting the environment through their extraction. Areas of designated landscape, nature conservation or heritage value have specific policies in place to either prevent, or only allow for mineral development in very special/exceptional circumstances (Street 1986) (UK 1981).
1982	USA	The American Society for Surface Mining and Reclamation (ASSMR) was formed, which had its roots in the society formed in West Virginia today known as the American Society of Reclamation Sciences (ASRS).
In 1987, the World Commission on Environment and Development published the Brundtland Report, which developed guiding principles for sustainable development.		
1986	USSR	Deputy Chairman of the State Planning Commission of the USSR published on 'Methodology for Determining the Economic Efficiency of Recultivation of Disturbed Lands Approved by Deputy Chairman of the State Planning Commission of the USSR'.
1989–1999	Germany	IBA-Ruhrgebiet was hosted. After 100 years of existence, the IBA format transformed from architecture transformation to regional infrastructure.

Year	Country	Practices
1990	Canada	In 1990, the Technical Advisory Committee of the Water Board in conjunction with staff of the INAC Land Resources Division drafted the 'Guidelines for Abandonment and Restoration Planning for mines in the Northwest Territories'.
1992	Russia	Federal law on 'subsoil' was formulated to regulate and exercise the use of subsoil.
1996	UK	The idea of the Eden Project is conceived by Tim Smit.
2000	Australia	The Strategic Framework for Mine Closure was published by the Australia and New Zealand Minerals and Energy Council (ANZMEC) and the Minerals Council of Australia (MCA).
2002	Canada	INAC 'Mine Site Reclamation Policy for the Northwest Territories' regarding disposition of liability related to mine closure.
<p>In 2002, Alan Berger published a chapter on 'Reclaiming the American West', highlighting cartography as an important tool for mine closure.</p> <p>2002 also saw the formation of International Council on Mining and Metals (ICMM), formerly called Mining, Minerals and Sustainable Development (MMSD), which provided guidelines on sustainable mining practices.</p>		
2000–2010	Germany	IBA-Lusatia. It continued the regional transformation and restructuring legacy of IBA-Ruhrgebiet.
2006	Australia	The Western Australia Guidelines for Mining Proposal, originally published under the provisions act, would now require all mining proposals to be submitted to the Department of Mines and Petroleum (DMP) to include a preliminary mine closure plan.
<p>In 2008, Alan Berger published a more comprehensive book elaborating ecological and technology-driven reclamation practices.</p>		
2010	Canada	Formation of National Orphaned/Abandoned Mines Initiative (NOAMI) for best practices on addressing abandoned mines.
2010	UK	Northumberland land art project for the reclamation of an abandoned coal mine site in Shotton by renowned landscape architect Charles Jencks is initiated.

Sources: (Thomas 1966); (Nephew 1972); (Environment 1976); (Street 1986); (UK 1981) (Bond & Piepenburg 1990); (British Columbia. Mine Closure Task Force. 1990); (Burley & Bauer 2000) (MMSD 2002); (Berger 2002) (Berger 2008); (Holmes & Stewart 2011); (Bottmeyer et al. 2012) Nguyen 2011); (Pike 2011); (Palazzo & Hollstein 2019) (Baumert 2020); (Ignatyeva et al. 2020)

Germany: To date, opencast lignite mining has altered 179,490 hectares of countryside in Germany, and since 1924, 313 settlements have been lost to lignite mines in the country (Appunn 2018). Germany is considered a pioneer in the concept of recultivation of mine land, and landscape practitioners such as Reinhold Linger and Otto Rindt played a significant role in highlighting the importance of the same (Baumert 2020). Germany has also been proactive with the concept of the Internationale Bauausstellung or the International Building Exhibitions (IBA) for the Ruhr and the Lusatian regions (Land 2010). The IBA has proven to provide a holistic vision for mine regions that help integrate the community within the process and looks at an interdisciplinary team to carry out the goals. It is a project driven through advocacy, carried forth through workshops and focus group discussions, with an organisational structure consisting of management, communication, project development and finance teams. The IBA recognises that mine closure is not limited to the aspect of recultivation but is a major spatial issue, which is why it works in three scales of local,

sub-space and regional level. It recognises both the tangible and intangibles in the given scales and integrates participation with innovation, which is driven by the idea of living in between landscapes (Land 2010).

USSR: The initial discussions on disturbed land were highlighted as ‘special soils’, which meant restoration procedure for agricultural land by IV Lazareva (Ignatyeva et al. 2020). This also reflects the understanding of recultivation used by VV Tarchevsky and EM Lavrenko (‘industrial botany’, ‘industrial biogeocenology’). Russian literature highlights that land recultivation was defined as a process where “a complex of various works (engineering, mining, reclamation, agricultural, forestry, etc.) are carried out over a certain period and aimed to restore the productivity of disturbed territories and to return them to different types of use” (Ignatyeva et al. 2020, p. 4). In 1960, the first major piece of legislation governing the reclamation of mined land in the USSR, ‘On the Conservation of Nature in the RSFSR’ conservation law, was enacted. Article 2 of the law identifies that lands suitable for agricultural use should be rehabilitated after the end of mining activity. After the passage of USSR Land Law of 1968, which extended to the lands across, it was mandated to store and replace the topsoil as a precondition for reclamation work. By 1976, a more comprehensive and detailed legislation was passed, titled ‘On Reclamation of Lands and Storage and Rational Use of the Fertile Soil Layer During the Mining of Mineral Resources and Peat and During Geological Exploration, Construction and Other work’ (Bond & Piepenburg 1990).

USA: In the United States, around 2.5 million hectares of natural forested landscape has been altered due to coal mining between 1930 and 2000 (Cheng & Skousen 2017). Kenneth Shellie, a landscape architect and planner, played an important role in the transformation of the American Midwest (Burley & Bauer 2000). Although working for sand and gravel quarries, he began a conversation and promoted the idea of surface mining as a transitional land use, introduced the concept of simultaneous excavation and rehabilitation and the importance of mining operations to create post-mining land use. His ideas resulted in fewer delays, efficient and increased profits due to surface mining planning (Burley 2001a). He also used his training as a landscape architect professional to suggest suitable vegetation as per the ecological needs of sand and gravel (Burley 2001b). Subsequent to the mine disaster of 1968 in West Virginia, there was an interest in coal mines and consequently regulation considering public safety was incorporated (Curran 1984). However, employing an aim-oriented approach, in 1974, the National Academy of Sciences of the USA defined in their research three categories of remedial land treatment and stated that industry favours rehabilitation, regulatory authorities favour reclamation and many ecologists favour restoration (Ignatyeva et al. 2020). In following years, the *Surface Mining Control and Reclamation Act of 1977* instilled a major change in reclamation practices and established federal control over coal mining, reclamation and environmental standards (Skousen & Zipper 2014). Further, the role of Alan Berger, in acknowledging the role of landscape architects and designers in the shaping of the post-mining landscape, proved to be an important addition to the process of mine closure in the USA (Berger 2002).

Canada: In Canada, most of the coal mines are found in the three western provinces of British Columbia, Alberta and Saskatchewan, with estimates of around 200,000 hectares of land being disturbed (Cheng & Skousen 2017). In 1969, British Columbia had its first legislation on reclamation (Mines 2017), and by the 1980s, Canada was already preparing restorations plans to acquire the natural assets of the region before mining operations. By 1990, Canada had straightened their guidelines on the restoration and abandonment plans. In 2002, the government introduced a mine reclamation policy that assigned mining companies full responsibility for post-closure after-effects. The year 2002 also saw works by McKenna identifying landscape engineering as an important tool for reclamation (McKenna 2002a). In 2010, the National Orphaned/Abandoned Mines Initiative was formed to encourage going back to legacy mines and ensure best practices for their closure (Holmes & Stewart 2011).

2.2 Global standards

In the past, discourse on mine closure was primarily informed by industry and mining companies of developed economies (Chaloping-March 2018). The current approach of mine closure planning is highly technical/managerial, involving stage-by-stage requirements that are mostly guided by legislation and principles of risk prevention and litigation avoidance. The factors shaping the design, implementation, and

monitoring of mine closure strategies are international in dimension. This is a positive development because global mining companies leverage themselves against each other in developing stringent standards of performance for themselves. However, the focus has been on new and future mines that neatly fit the formulations of a ‘planning-before-commencing’ approach that assumes a blank slate as a starting point for the mine closure process, envisioning a post-mining future. There are various mine closure standards, handbooks and toolkits across the globe, with the recurring theme of planning for closure at the onset of the mining process. The frameworks provided only add to the closure planning process, but do not provide overlap (Sánchez et al. 2014).

2.2.1 ICMM

ICMM is a global leadership organisation guided by the need for sustainable development in the pursuit of providing a standard in the complex process of closure planning. Earlier called Mining, Minerals and Sustainable Development (MMSD), ICMM evolved from a group of CEOs in the metals and mining companies to a more preeminent sustainable development platform after the Toronto Declaration in 2002. Over the span of two decades of its existence, the organisation has looked into issues ranging from not mining in world heritage sites to understanding the biodiversity and indigenous communities that are dependent on the natural resources. It also highlighted the importance of catchment-based water management for mine regions and issues pertaining to resettlement rights of indigenous populations.

The Intergovernmental Forum (IGF), which is a part of the MMSD, supports more than 75 nations committed to leveraging mining for sustainable development to ensure negative impacts are limited and financial benefits are shared. It is devoted to optimising the benefits of mining to achieve poverty reduction, inclusive growth, social development, and environmental stewardship. The IGF is focused on improving resource governance and decision-making by governments working in the sector. It provides a number of services to members including in-country assessments, capacity-building and individualised technical assistance, guidance documents and conferences, which explore best practices and provide an opportunity to engage with industry and civil society. The International Institute for Sustainable Development has served as Secretariat for the IGF since October 2015. Core funding is provided by the governments of Canada and the Netherlands.

The handbook called the ‘Planning for Integrated Mine Closure: Toolkit’, developed in 2008 on the mining and metals sector, is intended to help onsite practitioners and their support groups make sound decisions based on the consideration of closure in a holistic manner. It helps in providing a disciplined knowledgeable approach to closure planning so as to successfully negotiate the paths of the many risks and safety issues in the process of mine closure (ICMM 2008). It is to be noted that this standard is mostly looking at mines that are yet to be closed and not abandoned or legacy mines. It also mentions very little on the environmental impacts of closure, only limiting it to identifying it as a risk, but no framework or guideline as to how to integrate it into the closure planning.

2.2.2 ISO

The ISO 21795 document on Mine Closure and Reclamation Planning is launched through the ISO process and is led by Canada (Steenhof 2015). The standard has been under development since 2016, and it takes about four years for the standard to be approved and published. There are two parts to the standards. Part 1 explains key requirements, which include the important principles and elements for planning mine closure. Part 2 is the guidance document, which acts as a toolbox, explaining in detail considerations when planning. It doesn’t provide testing or monitoring methods or detailed engineering methods for construction and operation. The safety and risk aspect of mine closure, which the ICMM mentions, is not included. The standard is being developed for professionals, such as mine planners, designers, regulators, operators, environmental assessors, and also the community, indigenous people and stakeholders with any interest or stake in the mine and its closure. It is to act as an international resource that encapsulates best practices across various specialisations and disciplines involved with planning for mine closure and reclamation. The standard will help promote a consistency and quality in planning that will be made available to a wide range

of stakeholders, but especially countries with minimal access to best practices, and acts as guidance on the topic. But similar to ICMM, the guidelines are applicable to new and operating mine sites and not abandoned or legacy mines.

2.2.3 *Toolkits by APEC, World Bank and Organisation for Economic Co-operation and Development*

Additional guidelines since ICMM and ISO have been developed to provide the mining industry with more practical guidance on the application of the integrated mine closure approach and principles, including practices, processes, examples and case studies.

The APEC *Mine Closure Checklist for Governments* developed in 2018 is an important toolkit that considers all the possible complicated scenarios that may occur when a mine is being closed (APEC 2018). A more recent toolbox by the World Bank is an extension of the suggestions mentioned in APEC, albeit without a checklist but more detailed on direction and approach (World Bank 2021).

The Organisation for Economic Co-operation and Development (OECD) has formulated the Mining Cities and Regions initiative that aims to develop recommendations for improving regional development specific for cities and regions with resource extraction industries (OECD 2019).

2.3 Global visions

2.3.1 *Sustainable development*

Sustainable development consisting of 17 goals are part of the agenda to be achieved by 2030 and it may be applicable to any economic/industrial activity, including the mining sector, which is a major improvement because, in 1992, the goals of sustainable development were barely discussed in relation to the mining sector. The concerns related to the impact of the mining industry on the environment and society forced the largest mining companies to launch, in 1998, the Global Mining Initiative, also called MMSD or ICMM, to clearly define what sustainable development should mean to the industry and how it could be put into practice. Mine closure directly impacts the economy and the employment opportunities in the surrounding area – social and economic development also being the pillars of sustainable development. Maintaining an equilibrium among these pillars, depending on the interests of individuals, politicians, and companies, is important for the sustainability of mining projects at different lifecycles (Botezan et al. 2020). Spatial planning has the potential to integrate these three independent pillars of sustainable development, and landscape as an approach can help facilitate that.

2.3.2 *Just Transition*

Just Transition was a thought stimulated by the labour organisations and environmental justice groups who envisioned the need to phase out industries that were harming the workers and environment so that new pathways can transition them to more sustainable job opportunities. Over time, it led to the formation of the Just Transition Alliance in 1997, which was based out of San Diego, California.

In 2013, the International Labour Organization (ILO), in its 102nd session, adopted a resolution and a set of conclusions concerning sustainable development, decent work and green jobs, putting forward a policy framework for a Just Transition (ILO 2015). At the 2015 United Nations (UN) Climate Change Conference in Paris, it was insisted by the Just Transition advocates to include the vocabulary in the preamble (UN 2015). The same year ILO produced a guideline document for the governments across the world on how to formulate, implement and monitor the Just Transition policy framework, in accordance with national circumstances and priorities (ILO 2015).

World Bank in 2018 established a more comprehensive document on managing mine closure, elaborating on three important pillars across three different phases in mining. The document highlights nine important lessons involving policy development, financial budget for closure, stakeholder involvement, mitigating

labour impacts, pre- and post-lay-off planning and environmental reclamation (World Bank 2018). This is an important document that assimilates the mine closure problems across the globe and proposes a 3×3 matrix rooted in sustainable development but specific to the problems and issues of mine closure.

3 Discussion and way forward

Frederick Turner, in the chapter ‘Valuing Alternation’, states that reclamation began as a practical need, a public-health necessity, a legal problem, and a technological challenge (Berger 2008). Some important arguments that are suggested from the observations made above in the literature are:

1. Thoughts on reclamation of mines began due to the alterations in the landscape and the impact posed on the environment that were identified by landscape designers such as Otto Rindt in Germany and Kenneth L Schellie in Midwest America. In the 1970s, when the concept of mine closure gathered momentum in the disciplines of environmental sciences, engineering and technology, the conversation on landscape slowly took a backseat, when in fact it was the landscape designers who started the dialogue on disturbed landscapes. In 2002, McKenna acknowledged that the science of landscape engineering is integral to the process of closing a mine (McKenna 2002a). It is therefore argued that landscape as a science or an approach is a major determinant of how the post-closure scenery is imagined, used and celebrated. As with time, the future theories in landscape science such as nature-based solutions and landscape-scale conservation management need to be identified as research directions for sustainable mine closure.
2. The current standards and toolkit documents on mine closure and the understanding of landscape science as a framework is not incorporated. It is observed that the characteristics of the toolkits are directed at achieving targets, without a clear methodology. In 2008, when Alan Berger wrote about designing the reclaimed landscape, there was interest in ecologically sustainable thinking about the design and management of the post-industrial landscape (Berger 2008). More recently, with the interest in sustainable development and Just Transition, the open pit mines are being looked at as means for rehabilitation and redevelopment for future land uses, alternative land use and end land use (Gerner et al. 2011; Hattingh & Bothma 2013; World Bank 2021). The mining plan also outlines a reclamation procedure to restore the land to a productive post-mining land use (Skousen & Zipper 2014). These suggest a definite gap between the standards and the vision set for mine closure.

The utilisation of landscape science as a framework for mine closure is needed for the following reasons:

1. The method of site evaluation, which is integral in understanding the physical and geographical constraints and opportunities in the process of planning and closure of the mine.
2. The understanding of the human–nature relationship, which is integral to suggesting a solution rooted in socio-ecological balance of the region.
3. The ability to suggest an alternative purpose, which is integral in developing an identity for the region, propelling the region to economic sustainability.

It is therefore suggested that landscape frameworks for mine closure should be included and considered in the standards, handbooks and visions to strengthen them.

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