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Social, economic and environmental resilience through mine closures: why collaboration and partnership are key

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Abstract

Mining and metals operations, and the communities and regions that host them are inextricably linked. In a world experiencing significant disruptions globally and locally due to climate change, natural disasters, pandemics, geopolitical tensions, and economic transitions, the mining and metals industry can play an important role in strengthening social and economic resilience. Mine closure is a significant disruption that every mining region will experience. With planned mine closures around the world expected to increase over the next decade, the industry has a unique opportunity to improve closure performance and support social and economic transition within mining regions.

ICMM's Integrated Mine Closure Good Practice Guide (ICMM 2019) sets out the key elements underpinning successful transition: integration of closure considerations into the mining lifecycle, closure planning, closure-specific stakeholder engagement, implementation of closure activities, post-closure monitoring, maintenance and relinquishment. Most of these elements start long before operations cease, and they are iterative in nature. Nonetheless, successful closure and the realisation of post-mining futures for mining regions, remains challenging. Overcoming the barriers to successful post-mining regional transitions will require collaborative, multi-stakeholder approaches that are self-sustaining and designed for longevity.

This paper will give an overview of work ICMM is doing to support closure good practice across the industry. This includes understanding multi-stakeholder approaches that support asset transitions across diverse global contexts, as well as leveraging the need for urgent action on nature, to realise post-mining outcomes that benefit people and the planet.

Keywords: *asset transition, mine closure, nature, relinquishment, socio-economic resilience*

1 Introduction

At a local level, mining and metals projects can contribute to socio-economic development in various ways including through employment generation, regional infrastructure development and growth in local goods and services supply chains. Furthermore, many mining and metals companies intentionally invest in social and environmental initiatives in the regions in which they operate, with the aim of improving development outcomes (ICMM 2013). Given the strong impact that mining or metals projects have on host communities, from the development stage through to the (often decades-long) operational stages, it is no small challenge when a mineral development project reaches end-of-life. Mine closure has been an important topic for ICMM members since the early days of ICMM's establishment (Brock et al. 2019). ICMM first published guidance to support the industry with responsible closure in 2005 with the release of Financial Assurance for Mine Closure and Reclamation (Fleury & Parsons 2006). In 2008, ICMM published a Planning for Integrated Mine Closure toolkit (Brock et al. 2019). During the mid-2010's mine closure gained greater attention as dramatic falls in metals and minerals prices threatened the economic viability of mines and many were either closing or being put into care and maintenance. It became apparent that greater support for industry to embed closure considerations into life-of-asset planning was needed and ICMM updated the 2008 toolkit. This work

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led to the publication of ICMM's Integrated Mine Closure Good Practice Guide (2nd edition) in 2019 (Brock et al. 2019) and a suite of additional resources (Brock 2021). which support early closure planning and integration. An important characteristic of the Integrated Mine Closure Good Practice Guide (2nd edition) is the framing of closure as an opportunity for social transition, rather than closure as an end point.

As mining is a temporary land use, closure will be a phase of every mining or metals processing operation (Keenan & Holcombe 2021). However, mine closure need not inevitably represent a threat to the socio-economic development that was catalysed by the mineral development in the region, although this has been the historic experience in many regions in the past (e.g. Haney & Shkaratan 2003). Mining can play an important role in strengthening social and economic resilience within host communities, to help them prosper beyond mining, and indeed through a range of other disruptions in our ever-changing world. For example, mining companies can be foundational partners in the collaborations required to build community resilience to climate change, changing workforce dynamics with automation and artificial intelligence, local political upheavals and pandemics, as well as the economic transition that mine closure will bring to the region.

2 Barriers and opportunities to positive regional legacies

Over the past two decades, the global mining sector has undergone rapid growth resulting in larger mines and mines in previously unextracted areas (Jasansky et al. 2023; Maus et al. 2022; Sonter et al. 2020). The increasing rate of mine productivity can lead to socio-economic benefits for mining communities and host countries (Hajkowicz et al. 2011), yet mining is an exercise in depletion. Every active mine will eventually exhaust its resource and every mine will close. Successful mine closure involves delivering a positive legacy while balancing environmental protection and social wellbeing with financial performance (ICMM 2019). The challenge of delivering this positive legacy through closure is greatest for large-scale and open cut mines, and regions with single commodity mines and/or multiple mines facing closure (Everingham et al. 2022). The challenge is further exacerbated at older mines that commenced operations under regulatory frameworks and operating norms with fewer environmental and social requirements than at present.

2.1 Mine closure: global context

Recent efforts in literature have worked to map mining land use and identify areas of mining activity at both local (Esau 2023) and global (Maus 2022) scales. However, there is relatively limited information on the global number of mines approaching or in closure and post-closure phases. Keenan & Holcombe (2021) interrogated the S&P Global database and found records of 1,800 closed mines, the vast majority of which (1,719) are reported as being in a state of inactivity, with only one listed as successfully relinquished. Data from Everingham et al. (2022) suggests that this number will likely increase more than 50% within the next 10 years alone, with approximately 1,000 mines globally reported to be facing closure. Regionally, estimates for South Africa are that more than 20% of currently operating mines (i.e. 48 from 221 operating mines) will close within the next 10 years (Cole 2024) . In Australia (CSIRO 2023) 237 mines (> 10% relative to the currently ~2,200 active mines) are estimated to close by 2040, most of these precious and base metal mines (79 and 54 mines respectively). In the United States, the rapid shift away from coal-fired electricity generation (reduced to a capacity less than half of previous peak production, by 2026) will result in significant coal mine closures and economic impacts in coal-producing states (Feaster 2023).

In many parts of the world, forecast mine closures are clustered, which exacerbates both the environmental and socio-economic risks for these regions (Everingham et al. 2022). The most well-known risks include acid rock drainage and metal leaching, tailings dam failures, direct and indirect job losses, economic downturn, basic service disruptions and increases in illegal mining (Cole 2024). The economic impacts of clustered mine closures can be regionally crippling, for example in the Northwest Territories (Canada), four diamond mines which contribute 29% of the territorial GDP are schedule to close gradually by 2030 (ERM 2022). However, there are also examples where mine closure risks have been turned into opportunities and where creative, sustainable post-mining futures for communities have been realised through rehabilitation and repurposing (Keenan & Holcombe 2021; Marot& Harfst 2021; Whitbread-Abrutat & Lowe 2024). In light of the coming

wave of mine closures in every major mining region globally within the next 10–20 years, we feel that it is both timely and important to identify the emerging factors underpinning successful post-closure regional transitions, in order to overcome the barriers that exist to realising these successes in other regions.

2.2 Mine closure good practice as the foundation for regional transition

ICMM's Integrated Mine Closure Good Practice Guide (2019) sets out the key elements underpinning effective mine closure, laying the foundations for successful post-mining transition: integration of closure considerations into the mining lifecycle, closure planning, closure-specific stakeholder engagement, implementation of closure activities and post-closure monitoring, maintenance and relinquishment. Most of these elements start long before operations cease, and they are iterative in nature. Closure is not a discrete phase of the mining life cycle, it is a dynamic process that involves incorporating evolving information, ideas and challenges from the earliest stages of exploration throughout mine development (see Figure 1). Just as no two mining operations are the same, so too mine closure plans are unique and context specific. However, every operation striving to leave a positive social and environmental post-closure legacy will be balancing social, financial and environmental aspects and will benefit from an integrated and iterative approach to closure. ICMM's Closure Maturity Framework (2020) is a practical tool that supports mining companies at any stage of the life cycle assess their preparedness for closure within each of the 14 key elements outlined in the Integrated Mine Closure Good Practice Guide (2019).

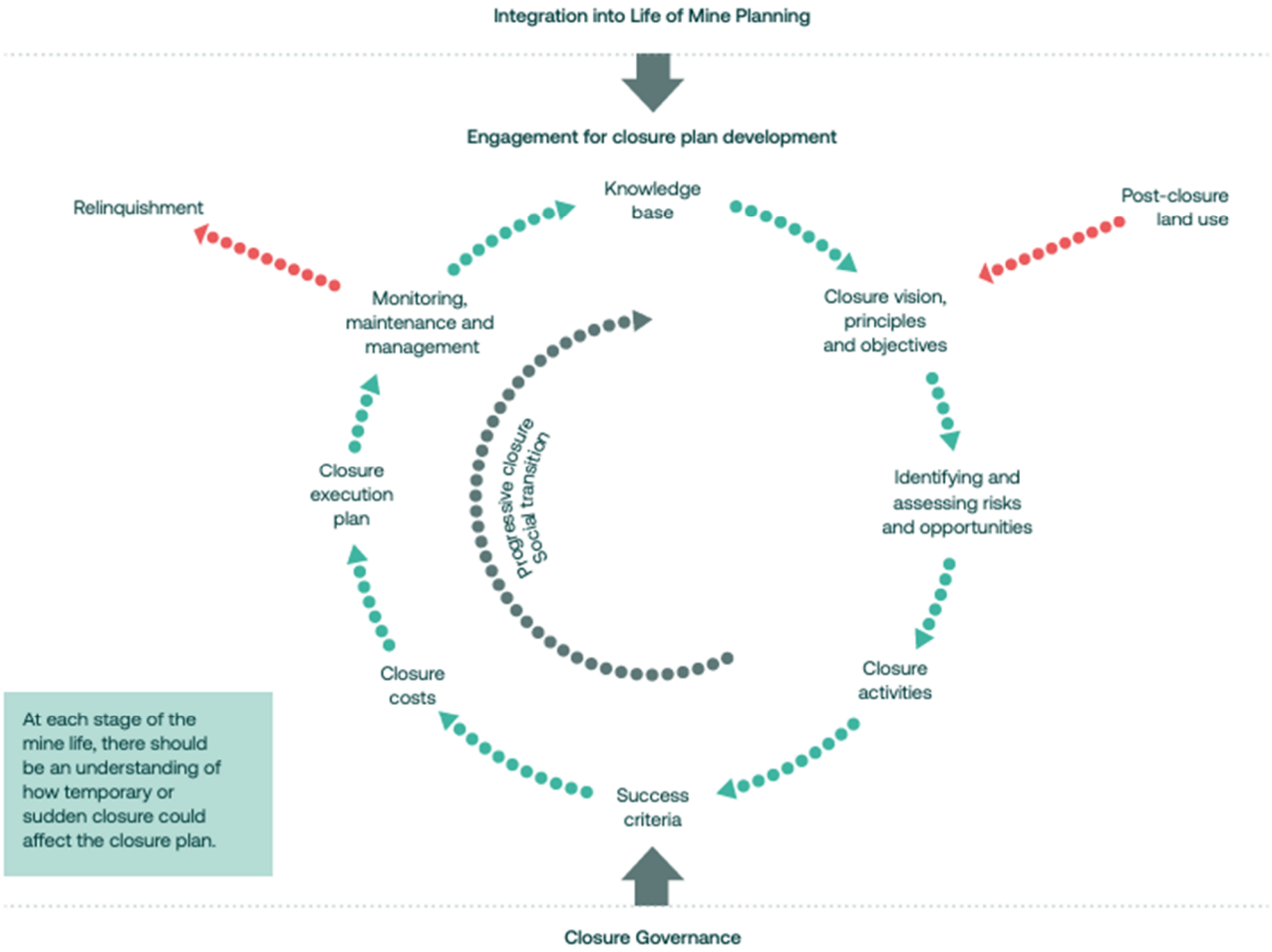

Figure 1 Integrated closure planning as an iterative process which emphasises social transition and progressive closure opportunities throughout life-of-asset (ICMM 2019)

As the knowledge base about an asset expands, the closure vision, principals and objectives must also be reviewed, in a stakeholder-inclusive manner as depicted in the iterative process shown in Figure 1. The ensuing benefits of this for the operator include earlier identification of closure risks and mitigation measures, refined closure cost estimates, and enhanced progressive rehabilitation and closure execution with the potential to progressively reduce liability. For stakeholders (regulatory and community) regular review of closure vision and objectives informed by data being acquired throughout life-of-asset, facilitates relationship-building, and a sense of shared ownership relating to closure decisions and the social transition for affected stakeholders.

2.3 Mine closure barriers that hinder regional transitions

Despite the extensive conceptual-level good practice guidance (ICMM 2019) and tools to support integrated closure planning and implementation across the mining industry (ICMM 2020), the realisation of post-mining futures for mining regions remains extremely challenging. Kragt & Manero (2021) evaluated Australian examples and identified that one of the greatest barriers is ill-defined or unrealistic target closure completion criteria. South African data suggests there are systematic barriers including a combination of the difficulty of rehabilitation and the long lead times to achieve it, coupled with the perception that:

> *'it is easier and cheaper to put a mine on indefinite care and maintenance or sell it to avoid closure.' (Watson & Oldade 2019)*

Globally, mine closure policies are also a contributing factor, with very few legislative frameworks providing a clear or achievable pathway for relinquishment and post-closure funding for maintenance of relinquished sites (Stevens et al. 2023). Furthermore, where post-closure transfer to a future landholder is an option, there is often reluctance on the part of stakeholders to accept, or sometimes manage, even well-defined residual risks (Finucane-Woodman 2019).

Within the industry, hard-to-shift perceptions about the cost of closure create barriers to good integrated mine closure practice. For example, standard industry practice of valuations that focus on revenues, pre-production capital expenditures and recurring operating expenditures, with little emphasis on the (highly uncertain and often discounted) long-term costs relating to closure, decommissioning or post-closure maintenance, render the present value of these future activities virtually negligible which adversely impacts risk-based decision-making relating to closure planning (Espinoza & Morris 2017). Poor preparedness for unplanned or sudden closure is also a significant factor. Laurence (2011) found that around 75% of 1,000 mine sites (from an international but Australia-centric dataset) between 1981 and 2009 were closed suddenly or ahead of the planned timeframe because of financial or technological issues, social or political instability and environmental pressures amongst others. Unplanned closure significantly increases the likelihood of poor outcomes given physical and social transition plans may be undeveloped and there is limited time to communicate with or build the capacity of relevant stakeholders. There are apparent opportunities for improved outcomes as a result of proactive, multi-stakeholder closure planning as early as possible in the mine life, implementing progressive closure practices, mature approaches to closure costing and including unplanned closure in company risk management systems.

2.4 Mine closure opportunities for mining regions

While the barriers to mine closure good practice are numerous, and the prior list is illustrative rather than exhaustive, it is obvious that successful mine closure and effective regional transition is complex. Purtill & Littleboy (2023) have even characterised mine closure as a 'wicked problem' – a social or cultural problem that is difficult or impossible to solve, due to the many interdependent factors. Mine closure and delivering a positive legacy is inherently complex as it involves optimisation of social, financial and environmental considerations (ICMM 2019). Rather than attempting to 'solve' the challenges of any one of these aspects in isolation, we propose that multi-stakeholder, multi-disciplinary models and a shared approach to risk will be required to turn the barriers (numerous as they are) to delivering positive regional legacies in mining regions, into realised opportunities. We also recognise the unique opportunity that global attention on

climate change, nature and biodiversity offers at present to drive the increased closure action that will underpin a just transition (UN CDP 2023) for these regions.

2.4.1 Multi-stakeholder approaches to asset transition

The capacity of a region to transition to post-mining alternatives is influenced by a myriad of contextual factors and characteristics; it is beyond the control of a single site, company or government body. Those with the strongest capacity to transition feature high human development (health, education etc), robust governance, only a moderate dependency on mining and less environmental modification and damage amongst other descriptors (Everingham et al. 2022). This gives clues as to what mechanisms to support successful transitions may look like and where they should focus their efforts.

Multi-stakeholder models including mining companies, regulators and local government, host communities and/or Traditional Owners, civil society organisations and researchers are critical to the success of mining transition. The context will be different for each asset and community and there is no one-size-fits-all approach, but we can be confident that no single entity can achieve an effective regional transition, in isolation. Historically, multi-stakeholder approaches to closure have not been well executed and new ways of partnering are needed if real, sustainable transformation is to be achieved. These new partnership models may include working to enable Indigenous Peoples and mining community aspirations including future land use and employment, and diversifying regional economies (CRC TiME 2024). Partnerships may be industry led and driven by a single mining company (see Golden Mine and Sullivan examples in Sections 2.4.1.1 and 2.4.1.2), led by an industry collective (see Northern Cape Shared Value Initiative example in Section 2.4.1.3), local/regional government led (see Oei et al. [2020] for an overview of the approach in Saarland, Germany) or community and/or Traditional Owner led.

Multi-stakeholder approaches require time and skills, on all sides of the partnership. Mining companies (specifically those employees with outward facing roles) and other partners require skillsets including those related to stakeholder interactions (associated with transition planning throughout the life of the asset) to improve the likelihood of a successful transition following mine closure. Companies must consider how to grow and strengthen these skillsets amongst their workforce throughout the life of mine, well before closure.

Within the realm of multi-stakeholder models for asset transitions, there is huge potential for greater and more meaningful participation of Indigenous Peoples and Traditional Owners. Having Indigenous Peoples as vital partners with mining companies and governments to co-create post-closure visions provides the highest potential to bring localised economic opportunities and instil cultural values and significance (Bond & Kelly 2021). At their Weipa operations, Rio Tinto are working with communities to understand the significance of the cultural and natural heritage of the environments they operate in. Since the early 2000's they've been working closely with the Traditional Owners and local Aboriginal people who have generously been sharing their knowledge and experience. Together they are now rehabilitating mined land with culturally significant species of native plants, using seeds collected by the community themselves, which Traditional Owners use for food, medicines, and ceremonial purposes. As they work, seed collectors earn an income and pass their knowledge on to the next generation (Rio Tinto 2023).

Similarly, at Rio Tinto's Gove site, where bauxite mining operations will cease later this decade, Rio Tinto is engaging with Traditional Owners in preparation for closure. The company formed a reference group with Traditional Owner organisations and government bodies to work collaboratively on potential transitional issues and to facilitate the planning for a positive post-mining future (Northern Territory Government 2024). Rio Tinto uses technology to illustrate future rehabilitation processes which give insight into how the land may look in the future. This gives Traditional Owners the opportunity to see their future aspirations and share their feedback with the company. The company is also working with local communities to grow native plants that are then used to rehabilitate around 120 hectares of land. To support economic diversification and stimulate new opportunities in the region, Rio Tinto partnered with the government to fund the establishment of an independent not-for-profit company in 2014, which is financing business growth projects and providing affordable housing for businesses to accommodate new employees (Rio Tinto 2024).

2.4.1.1 Case study: Golden Pride mine

A practical example of an integrated, progressive and stakeholder-inclusive approach to closure can be seen at the Golden Pride mine in Tanzania (Stevens 2022). Golden Pride Mine was an open pit gold mine that operated from 1998 to early 2013. The operator, Resolute Mining Limited, chose to implement a good practice mine closure approach in the years before closure, with the aim of ensuring the physical and chemical stability of the closed mine site and productive post-mining land use that would support community resilience. Community and government stakeholders were proactively engaged at least four years before closure, to understand how Golden Pride could play a part in a viable post-mining future for the region. Stakeholders were involved in planning for and evaluating various post-mining land uses (e.g. prison facilities, training centre, provision of water for the community). Three years before closure the workforce was actively engaged in preparation for the post-mining transition. The progressive rehabilitation activities that had been undertaken at Golden Pride during operations – to test approaches to covering and reclaiming waste rock piles and tailings storage area – informed the viability of the post-mining land uses and underpinned the successful closure and relinquishment of the site to the Government of Tanzania in 2015; after a short period of post-closure monitoring.

2.4.1.2 Case study: Teck's Sullivan Mine

The Sullivan Mine operated by Cominco Ltd (later Teck Resources) in southeastern British Columbia demonstrates the lasting legacy of an early and integrated approach to closure and post-mining transitions. The Sullivan Mine was operated from 1909 to 2001 and was a critical element to the social and economic foundation of the city of Kimberley, being the single largest contributor to the town's tax base and the largest employer (Teck Resources 2023). Teck Resources engaged in closure planning in earnest approximately 10 years ahead of the planned closure in 2001. This approach combined municipal leadership aspects and a collaborative approach to post-mining transitions from the operator. Teck Resources worked with the Sullivan Public Liaison Committee (SPLC) as a multi-stakeholder forum to implement the closure plan for the mine and collaboratively develop the transition plan for the town, which focused on establishing a tourist trade and recreational facilities such as a local ski resort, golf course and hiking trails, as well as a retirement community. During the closure planning and closure period, more than 30 community and stakeholder meetings were held to review and comment on the proposed reclamation plans (Teck Resources 2023). Over the transition period, the loss in mining jobs was found to not coincide with a large decrease in community population (Shandro et al. 2011), this is largely attributed to the community-based sustainability planning

This collaborative approach to post-mining transition and economic diversification also extended to the establishment of SunMine, a pilot solar panel project on Sullivan Mine land. The City of Kimberley initially co-financed and owned SunMine, while Teck provided the land and donated CAD 2 million to the project. Teck subsequently purchased SunMine and the energy generated is utilised onsite or fed back into the grid (Teck Resources 2023). The transition from closure to post-closure within this community can be described in three phases:

1. a shift in economic influence due to diversification initiatives
2. a shift in community dependency to a more independent position
3. a shift in corporate views to a more collaborative approach (Shandro et al. 2011).

Some 20 years on from the initial closure of the mine, the community of Kimberley has transitioned into a thriving community and has experienced population growth of approximately 25% between 2001 (closure) and the most recent census in 2021 (Statistics Canada 2021). Although the SPLC was originally started to transition the town through the closure period, it was re-launched in 2021 to facilitate information sharing and discussions about future mine-related activities, initiatives and ongoing land and water management at the mine.

2.4.1.3 Case study: The Northern Cape Shared Value Initiative

The Northern Cape Shared Value Initiative was initiated in 2017 by four mining companies (Assmang, Kudumane Manganese Resources, Anglo American Kumba Iron Ore and South32) operating in the Northern Cape, South Africa (Global Africa Network 2021). Mining has long been the largest private-sector employer in the region. The shared value approach was born out of the intention to enable communities to benefit from the mine operations but not become dependent upon them, helping them to thrive after the mine itself has closed. It aimed to collaborate with (not to duplicate) government's existing development agenda and framework, and to engage and integrate with any stakeholders concerned with sustainable development and transformation – including civil society and community members themselves (AngloAmerican 2021). The approach started by identifying socio-economic development opportunities with the greatest potential in a region via spatial analysis and planning, which enabled partnerships to be built with diverse stakeholders. In 2020, the spatial planning exercise was finalised and socio-economic development projects were identified. Impact Catalyst became the implementing agent. Its programmes included development of the agricultural and tourism sectors, capacity building of municipality to deliver services, provision of information and communications technologies to schools and communities. This initiative demonstrates collaborative effort to achieve greater socio-economic impact within communities impacted by mining and in doing so, building their capacity to transition at a later stage. It continues to leverage collaboration of partners at a broad scale, across a variety of sectors to achieve results beyond the reach of individual organisations.

2.4.2 Global focus on nature to drive the increased the closure action underpinning a just transition

Globally there is an urgent call for action to halt and reverse the loss of nature by 2030 and support the recovery of nature by 2050 (UNEP 2022). This is often referred to as the global goal for nature, or the goal for a nature positive future. However, in addition to being a goal, nature positive is also an approach focused on creating resilient landscapes and communities through supporting the restoration of healthy functioning natural systems. Nature positive approaches are about enriching biodiversity, storing carbon, purifying water and reducing pandemic risk (among other things). For business, taking nature positive action translates as a movement away from reducing harm and pollution, towards a business model focused on regeneration, resilience and recirculation. While some may feel that a focus on biodiversity and nature is a threat to creative, economic post-mining land uses that support regional transitions, we argue this is not the case.

Nature has four physical realms: land, ocean, freshwater and atmosphere; with people at the centre of this conceptualisation of nature, because communities, businesses and individuals are both dependent on and impact these realms (TNFD 2023a). The global goal for nature has resulted in the rapid expansion of disclosure frameworks and requirements on companies, with the aim of supporting investment decision-making and the flow of finance away from nature negative actions and towards nature positive investments (TNFD 2023a). This increased focus on the realms of nature, with people at the centre, and the implications it has for investment and business decision-making bring together all three of the elements that closure optimisation involves: environmental, social and financial considerations. Closure planning is an iterative and risk-informed process; therefore dynamically incorporating consideration of nature impacts, dependencies, risks and opportunities as required by emerging nature-related disclosure frameworks (e.g. the Taskforce on Nature-related Financial Disclosures), is a unique opportunity to drive increased closure action on the ground. Furthermore, assessing nature-related impacts, dependencies, risks and opportunities is done at the ecosystem or landscape-level, so inherently interfaces with mining host communities. Companies need to decide actions and set targets in response to these nature-related assessments, in collaboration with stakeholders, which also mirrors stakeholder-informed integrated closure-planning good practice and will require multi-stakeholder approaches where actions involve shared ownership within the landscape (TNFD 2023b).

ICMM has developed a Nature Position Statement (2024) with key commitments that contribute towards the Kunming-Montreal Global Biodiversity Framework and a nature positive future. The Nature Position Statement covers five spheres of influence (Figure 2):

1. Direct operations – stewarding operational lands and natural resources to drive positive change for nature and those that depend on it, now and in the future.
2. Value chain – partnering with suppliers, customers and key stakeholders to support value chain action for nature by 2030.
3. Landscapes – collaborating and building capacity with local and regional partners – including Indigenous Peoples, land-connected peoples and local communities – to support and enhance healthy, resilient ecosystems and the livelihoods and wellbeing of people that depend on them.
4. Systems – creating and enabling conditions to catalyse broader nature positive change and transformation within and beyond our industry by 2030.
5. Governance and transparency – enabling business transformation and embedding nature positive approaches through commitments to areas such as integrating nature considerations into business decision-making and disclosing material nature-related impacts dependencies, risks and opportunities.

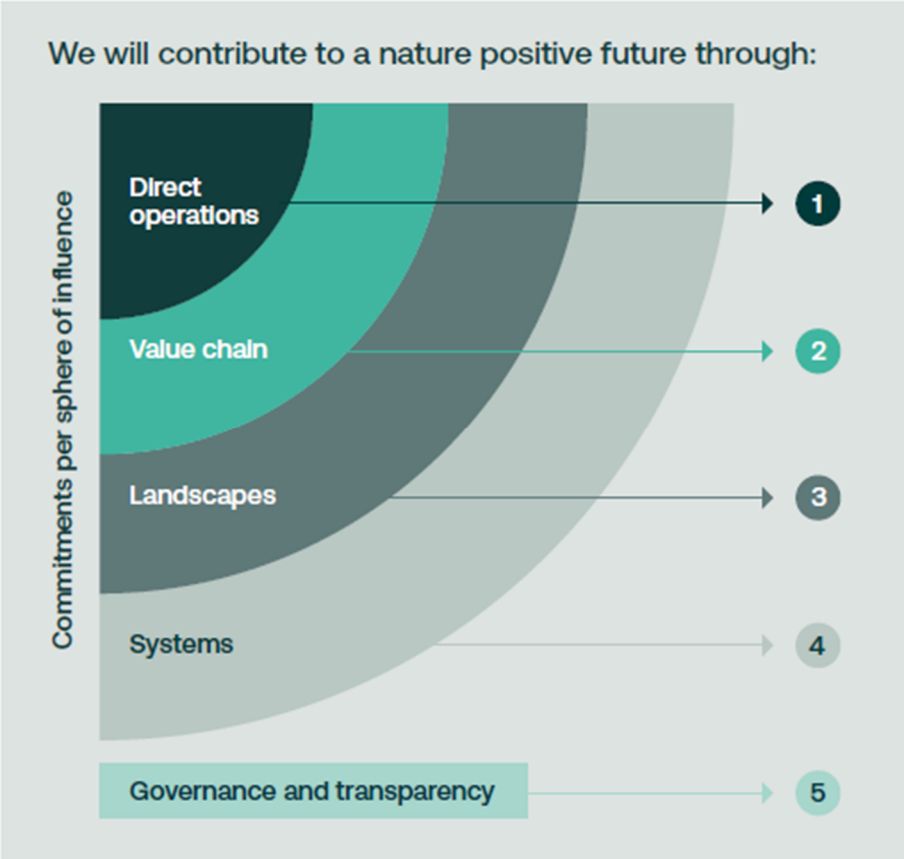

Figure 2 ICMM Nature Position Statement spheres of influence

Rehabilitation, restoration and development of sustainable post-closure land uses play crucial roles in achieving the commitments in each of these spheres of influence. However, landscape-level approaches (sphere 3) is an area where closure, nature and multi-stakeholder approaches can intersect powerfully. Post-mining land use planning, and explicitly seeking nature positive opportunities at the ecosystem or landscape-level (which includes the host communities), has the potential to connect formerly fragmented ecosystems and reinstate ecosystem services that are needed for broader ecological, agronomic, social

and/or cultural uses (Hattingh et al. 2019; Maier et al. 2023). Repurposing of impacted land and the creation of alternative sustainable land uses that support ongoing economic development while enhancing the regional biodiversity values is also an opportunity to contribute towards resilient post-mining communities and a nature positive future.

There is a multitude of practical ways to operationalise closure good practice in support of a nature positive future at every step of the closure process (knowledge base, closure vision and objectives, risks and opportunities assessment, closure activities, success criteria, costs and execution, and monitoring, maintenance and management), e.g. see Maier et al (2023). Rather than conflicting with the development of thriving post-mining communities, a nature positive approach is a stakeholder-centric approach and underpins the development of resilient post-mining landscapes and regions. The growing focus on nature by investors and stakeholders is a lever that closure practitioners can use to assist in articulating and communicating the business case for increased closure action on the ground, and for prioritising sites within a portfolio for urgent closure planning and execution.

3 Conclusion

Within the next 10 years there will be approximately 1,000 more closed mining sites than the ~1,800 presently closed and inactive sites listed in global databases. This represents an opportunity for the mining industry to contribute to a positive legacy and build socio-economic resilience within a multitude of mining host communities around the world. However, the evidence indicates that closure, post-closure relinquishment and regional transitions for mining communities, are challenging. As closure involves balancing of sometimes competing environmental, social and financial considerations, the barriers to closure and regional transition will not be solved by the mining industry alone. Multi-stakeholder approaches are required to build local social, economic and environmental resilience post-mining and to establish frameworks for sustainable development in mining regions over the long-term. Acknowledging the need for new approaches and partnerships for closure and transition also highlights that historical approaches to closure cannot continue to be the norm. Furthermore, the present global momentum relating to nature positive, offers an opportunity to elevate the internal business case for closure action and could be a catalyst for the increased closure action that is the foundation for successful regional post-mining transitions.

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