

## South African Mining Innovation Ecosystem Review

A review of the South African mining innovation ecosystem's performance between 2017 and 2022



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## Glossary

4IR – Fourth Industrial Revolution

AU - African Union

**B-BBEE** – Broad-Based Black Economic Empowerment

**CEMI** – Centre for Excellence in Mining Innovation

CGS - Council for Geoscience

**CMIC** – Canadian Mining Innovation Council

**COSIA** – Canadian Oil Sands Innovation Alliance

**CRC** - Cooperative Research Center

**CSIR** – The Council of Scientific and Industrial Research

**CSIRO** – Commonwealth Scientific and Industrial Research Organization

**DMRE** – Department of Mineral Resources

**DSI** – Department of Science and Innovation

**DTIC** – Department of Trade, Industry and Competition

**ESD** – Enterprise and Supplier Development

**ESG** – Environmental, social, and governance

**EU** – European Union

**GDP** – Gross Domestic Product

HQ - Headquarters

ICMM - International Council on Mining and Metals

ICT – Information Communications Technology

**IDIA** – the International Development Innovation Alliance

IMII – International Minerals Innovation Institute

**IP** – Intellectual Property

**MEMSA** – Mining Equipment Manufacturers of South Africa

MHSC - Mine Health and Safety Council

MMP - Mandela Mining Precinct

MoU - Memorandum of Understanding

**MOSH** – Mining Industry Occupational Safety & Health

MQA – Mining Qualifications Authority

**NECI** - National Entrepreneurship Context Index

NRC - National Research Council

**OECD** – Organization for Economic Cooperation and Development

**OEM** – Original equipment manufacturer

**PDAC** – Prospectors and Developers Association of Canada **PE** – Private Equity

**R&D** – Research and Development

**RIIS** – Research Institute for Innovation and Sustainability

**SADC** – Southern African Development Community

**SAIMM** – Southern African Institute for Mining and Metallurgy

**SAMERDI** – South African Mining Extraction, Research, Development and Innovation

**SATCAP** – Successful Applications of Technologies Centred Around People

**SMME** – Small, Medium and Micro Enterprise

**SSMB** – Small-Scale Mining and Benefication

**STEM** – Science, technology, engineering, and mathematics

**TEA** – Total Entrepreneurial Activity

TIA - Technology Innovation Agency

TRLs - Technology Readiness Levels

TSM - Towards Sustainable Mining

VC - Venture Capital

WiMSA - Women in Mining South Africa

YoY - Year-on-Year



## **Acknowledgements and Copyright**

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## **Executive Summary**

This study reviews the South African mining innovation ecosystem's performance between 2017 and 2022 and provides an international benchmarking with other prominent mining industries across the globe. The main objectives of this work are to evaluate the ecosystem's overall health, to ensure the longevity of the local mining industry, to enable the industry to drive economic development in South Africa and to facilitate the industry's competitiveness within the global market.

Since 2017, the Minerals Council South Africa's Modernisation department, in collaboration with other key industry players, has made significant efforts to strengthen South Africa's mining innovation ecosystem and to further develop the nation's mining-related capacities. The Minerals Council's strategy includes Strategic Goal 03: "Minerals Council and members to implement a positive contribution model (including to the NDP)". Within this goal, a key objective is to "promote innovation and R&D for the sector". This entails facilitating "collaborative efforts on innovation that will contribute to achieving zero harm, improving productivity and competitiveness and creating sustainable and socially acceptable mining". This work has largely been driven by the industry's people-centric approach to modernisation and is necessary to ensure the longevity of the industry, drive increased economic development in South Africa, and enable the industry to compete within the global market. The Innovation Ecosystem Review was commissioned to ensure continued prioritisation of the appropriate initiatives and resources to further develop the mining innovation ecosystem, a review of the progress made over the last five years.

The International Development Innovation Alliance (IDIA), which offers the analysis framework used in this review, identifies nine goals as the main objectives on which ecosystem-strengthening initiatives typically focus. The effectiveness and efficiency with which an innovation ecosystem transforms innovative inputs into outputs and outcomes is demonstrated by these nine goals, namely: i) Building Human Capital, ii) Access to Finance, iii) Supportive Markets and Infrastructure, iv) Policies and Regulation, v) Innovation Culture, vi) Networking Assets, vii) Equitable and Inclusive Participation, viii) Pathways to Scale, ix) Collective Approach.

Using the IDIA framework, a gualitative analysis and strength ranking of the mining ecosystem was developed. The review concluded that South Africa's mining innovation ecosystem is underdeveloped, with encouraging advancement between 2017 and 2022. While well-established networks and partnerships for collaboration exist, ineffective policies and public sector processes continue to hamper innovation. Attempts to remedy these bureaucratic inefficiencies have led to the establishment of the Red Tape Reduction (RTR) task team and the DMRE policy review. Furthermore, there is a lack of access to finance, insufficient human capital development and other elements vital to driving and supporting innovation. As such, innovation is often driven by larger mining houses that have adequate resources. Smaller companies and start-ups struggle with inadequate resources and limited market access, which further limits their capacity to invest in innovation. The increasingly dilapidated state of infrastructure in the country is also a significant threat to the industry.

Overview of South Africa's mining ecosystem performance

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A retrospective analysis has been done for 2017, which marks the beginning of the Modernisation Partnership with RIIS. This enables a comparative analysis of the ecosystem since 2017 and assess the impact of the partnership's initiatives on the ecosystem as a whole. Whilst progress is required in each of the nine IDIA goals, prioritizing the development of infrastructure, scaling capabilities, and financing mechanisms is vital to enable the further development of the mining innovation ecosystem in South Africa, and to ensure the longevity of the mining industry in the country.

## Since 2017, the performance rating has significantly improved in three areas:





## Executive Summary

North America and Europe continue to shift away from mining (extraction) as the core focus, towards developing supporting technologies for activities along the mining value chain. This has been achieved through networking assets amongst mining houses, OEMs, and research institutions. Many of the countries in these regions have an array of convenors and established industry networks working together towards common innovation outcomes, often supported by enabling policies and access to adequate and appropriate finance. For the South African mining industry to achieve similar success, it is imperative that the industry encourages knowledge sharing between stakeholders, adopts a long-term view to mitigate regulatory uncertainty, leverages the relative strength of other manufacturing industries (e.g., the automotive industry) and provides incentives and a compelling value proposition to facilitate the retention of human capital within the local mining industry. Suppliers can also drive innovation by leveraging convenors, research centres, and other industrial organisations, which help share the risk and cost for innovators. Regarding sustainability, the Towards Sustainable Mining (TSM) Initiative has become a global leading practice in the improvement of performance on ESG issues. The initiative has been adopted by multiple countries across the globe and will soon be considered in South Africa"

## Lessons for South Africa from the global mining ecosystem

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### CANADA

Look towards implementing an initiative like the Towards Sustainable Mining (TSM) initiative, to ensure that mining companies manage key environmental and social risks more effectively and take accountability for their ESG commitments, through the investment into supporting RD&I initiatives.

#### USA

Develop efforts to emulate the United States' ability to effectively leverage its enabling policy climate to attract foreign investment. This can be achieved by addressing some of the major policy and regulatory inefficiencies that hinder the growth of the local mining industry.

### CHILE

The Mandela Mining Precinct may benefit from adopting a similar approach to Expande Minería, which has succeeded through broader collaboration across industries enabled by its links to an industryagnostic convenor. The SA mining sector can leverage the relative strength of other manufacturing industries, such as automotive, chemicals, clothing and textiles.

#### BRAZIL

#### EUROPE

SA can adopt a similar collaboration role as the EU in supporting the mining industry to develop holistically, and potentially enable resource-rich regions within SADC and AU to develop into global commodity suppliers, with South Africa as a leading technology provider. Future implementation of the requisite policies and enabling factors is an essential consideration to allow for the shift in value offering from extraction to other value-chain activities.



### CHINA

Government agencies, tasked with driving innovation should focus on implementing appropriate supporting policies and funding mechanisms to drive innovation across various industries. At the same time, the mining industry's strategies for growth and economic development must maintain nature, health, and democratic freedom.

#### RUSSIA

In order to aid with retention issues, the South African mining industry should consider providing a compelling value proposition that gives its talent pool the chance to hone, use, and benefit from their knowledge and abilities, instead of them moving into other sectors or migrating to other countries, as is the case in Russia.

### AUSTRALIA

Much like in Australia, South African suppliers should consider ways in which they can better leverage and utilise coordinating agencies, research centres, and other industrial organisations. This will help share the risk and cost for innovators, create communication spaces and systemically tackle common problems.

#### INDIA

Establishing an ecosystem where knowledge sharing without secret sharing is crucial as South Africa seeks to increase collaboration and networking in the mining sector, to support increased innovation.

Public and private sector stakeholders should adopt a longer-term view to reduce the impact of high levels of corruption and regulatory uncertainty on the hampering that these have on innovation within the industry. As seen in the regulatory issues and corruption that led to the dam disasters and other environmental degradation in Brazil.



## Introduction

The South African mining innovation ecosystem has been strengthened through

people-centric modernisation since 2017 thanks to the collaborative and inclusive initiatives of the Mineral Council's Modernisation Department. In August 2022, an assessment of the South African mining innovation ecosystem was started. It was influenced by internal strategic planning initiatives and the post-implementation evaluation of the Strategic Partnership between the Minerals Council South Africa and the Research Institute for Innovation and Sustainability (RIIS) for People-Centric Modernisation that took place from 2019 to 2021.

Modernisation is a strategic priority for the Minerals Council South Africa, aiming to create an enabling environment for industry-wide change. The Mineral Councils strategic focus is modernisation, which strives to foster transformation across the industry.

This Innovation Ecosystem Review analyses the South African mining innovation ecosystem's performance and evolution between 2017 and 2022. The approach, as shown in Fig. 1, was used in order to gain the relevant insights for the review.

Firstly, the ecosystem is analysed using leading global practices identified through desktop research and stakeholder engagements, to build a qualitative analysis and strength ranking of the mining ecosystem. The International Development Innovation Alliance (IDIA), which offers the analysis framework used in this review, identifies nine goals as the main objectives on which ecosystem-strengthening initiatives typically focus.

The effectiveness and efficiency with which an innovation ecosystem transforms innovative inputs into outputs and outcomes is demonstrated by these nine goals, namely:

- i) Building Human Capital
- ii) Access to Finance
- iii) Supportive Markets and Infrastructure
- iv) Policies and Regulation
- v) Innovation Culture
- vi) Networking Assets
- vii) Equitable and Inclusive Participation
- viii) Pathways to Scale,

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ix) Collective Approach.

A SWOT analysis and international benchmarking are then used to identify opportunities and barriers to strengthen the innovation ecosystem. It will be utilised to inform the interventions pursued in the Strategic Modernisation Partnership (2022 – 2026) and beyond.

## Methodology used for the Innovation Ecosystem Review

Desktop Stakeholder Research/ Mapping & **Prior Work** Interviews Analysis Approach/ Methodology Innovation Intervention Ecosystem Assessment



## The IDIA framework – using global leading practice framework to assess the mining ecosystems performance

IDIA sets out three types of ecosystems. The definitions of innovation ecosystem types fall along a continuum depending on which actors, assets or relationships they emphasise. A strong or successful ecosystem is commonly defined by its ability to mobilise actors, assets and relationships to provide a supportive enabling environment for innovation and social entrepreneurship to flourish.

### **Entrepreneurial ecosystem**

The innovator is placed at the centre of the model, and the focus is to fill in gaps and resources for entrepreneurship and meet the innovator's needs.

Refers to programmes that place emphasis on the ecosystem's capacity to translate ideas into solutions and reinforce connections among actors, to facilitate scaling through various partnership models.

Innovation-oriented

Source: Adapted from "Strengthening Innovation Ecosystems", The International Development Innovation Alliance (IDIA), 2021

### **Mission-driven (or Purpose-driven)**

The emphasis lies on creating a shared sense of purpose and identity among a wide variety of ecosystem actors and mobilise them to address a shared mission or challenge.

For the Minerals Council's mission to strengthen the mining cluster through modernisation and innovation, it is proposed that the South African Mining innovation ecosystem be analysed as a purpose-driven ecosystem.



## Innovation ecosystem strengthening goals to characterise the mining sector

The IDIA framework provides nine goals that typically determine how efficient and effective an innovation ecosystem is in converting innovation inputs into outputs. The goals are not mutually exclusive, and many of them are overlapping.

O1       Building Human Capital         O2       Access to Finance         O3       Supporting Markets and Infrastructure	The process of growing the knowledge, capacities, skills, relationships and expertise that enables people to innovate and support innovation processes.	Strong entrepreneurial ecosystems need a multifaceted range of financial institutions to provide various financial products and services. The lack thereof remains one of the most important factors to address for productive and sustainable entrepreneurship.	Access to markets determines the access that innovative businesses have and the market opportunities that shape success or failure. In domestic markets, which are usually most relevant for entrepreneurs, the maturity of infrastructure supporting their functioning is critical.
04       Policies and Regulation         05       Innovation Culture         06       Networking Assets	Policy and regulatory environments are powerful in determining how well innovation processes and actors operate. They can actively prohibit innovation through strict rules, high levels of risk adversity and institutional practices that encourage resistance to change.	Culture is the foundation for the entire innovation process. Creating a culture supportive of innovation and entrepreneurship often requires changing the mindset of a population to align with changing needs.	Networks are crucial for innovators to stay abreast of developments, find funding or supporters, expand their market reach, tap into a larger base of ideas and technology, find complementary expertise and access specific skills and competencies.
07   Equitable and Inclusive Participation     08   Pathways to Scale	Innovation has the power to address complex development and social justice challenges, but it is critical to avoid recreating or deepening the inequalities that exist in established systems	The road to scaling is often unclear and unique for each innovation, while the context in which it operates may require significant effort.	Actors within an ecosystem are often disconnected and unaware of common challenges or the mutual benefits that a targeted collaboration might provide.
O9 Collective Approach			

Summary of Mining Innovation Ecosystem Performance →



## Overview of the analysis of the evolving mining ecosystem performance

South Africa has an underdeveloped mining innovation ecosystem. Although ecosystem actors have well-developed networks and partnerships for collaboration, many policy processes and interfaces with the public sector are inefficient and delay innovation. The industry also requires further innovation scaling capacity and capability development and is faced with limited financing options for SMMEs and poorly managed infrastructure. A retrospective analysis has been done for 2017, which marks the beginning of the Modernisation Partnership with RIIS. This enables a comparative analysis of the ecosystem since and the impact of the Partnerships initiatives on the ecosystem as a whole.



LEGEND Level of development of the goal as of 2022 Non-existent Under-developed Developing Developing Fully-developed



## **Ecosystem SWOT Analysis**

## **STRENGTHS**

#### Goal 1 Building Human Capital

• Academic institutions and science councils are becoming more IP savvy, using more cost-effective, efficient, and fit-for-purpose mechanisms to register IP.

#### **Goal 2** Access to Finance

• Strong desire to support innovation and innovators. This has been seen in increased levels of funding for the establishment of innovation centres and an increasing number of available funding mechanisms available to innovators.

#### **Goal 5** Innovation Culture

• Entrepreneurial spirit and great attitude within graduates that industry can benefit from if well channelled.

#### Goal 6 Networking Assets

- The shift in MMP strategy and approach aligns with the industry needs and direction and enables the development of solutions without reinventing the wheel.
- Minerals Council is trusted in the Industry and beyond.
- Collaborative approach to regulation/policy development with some government bodies and their partners, such as the MHSC policy creation process.
- The post-covid way of working has increased opportunities for collaboration.

#### **Goal 7** Equitable and Inclusive Participation

Increased openness towards equitable and inclusive participation by most mining companies

## **WEAKNESSES**

#### **Goal 4** Policies and Regulations

- Challenges with the design and administration of the R&D Tax incentive discourage innovation.
- Top heavy administrative structures often lead to the positioning of some government departments against each other rather than for a unified agenda
- There is a lack of alignment on the approach to achieving transformation, which adds uncertainty and leads to additional risks in compliance.
- There is a lack of expertise and understanding of the mining operational value chain among state bodies and organised labour unions.
- Collaboration between organisations (particularly government) often does not produce impactful outcomes.

#### Goal 5 Innovation Culture

- Innovation seems to be growing within Minerals Council members but seems to be lagging in other areas of the ecosystem.
- The perception of automation leading to job losses hinders technology adoption.
- Many start-ups' self-perception of their capabilities is too high start-ups due to a lack of benchmark in all categories required for success.
- Individuals' positions in a future ecosystem are not perceived as better than in the current state, resulting in resistance to change and a defensive stance towards collaborative innovation

#### **Goal 7** Equitable and Inclusive Participation

• The use of traditional mining methods in South African mines, along with the lack of technology adoption, leads to a higher unskilled and semi-skilled labour requirement and hinders diversity and inclusivity.



## **Ecosystem SWOT Analysis**

## **OPPORTUNITIES**

#### Goal 1 Building Human Capital

• Provide guidance and training for start-ups on process, structure and quality level-setting required by the mining sector.

#### Goal 2 Access to Finance

- Incentivise mining companies to direct their required spending commitments, like the Mining Charter Human Resource Development obligation, into innovation initiatives.
- Consider alternative financing mechanisms such as stream financing.
- Create a climate of exploration investment with tech in South Africa to shift from the sunset industry perception.

#### **Goal 4** Policies and Regulations

- Support industry bodies to provide technical support and advisory services to policy and regulation developers (vs advocacy).
- Improve the awareness of the tax incentive application processes and collaborate with key stakeholders to improve their design.

#### **Goal 5** Innovation Culture

• Educate the ecosystem on what the process of innovation entails.

#### Goal 6 Networking Assets

- De-centralisation of innovation hubs to other mining centres.
- Increase the role of Mandela Mining Precinct can have as a centralised innovation driver.
- Connect start-ups with Mining houses to identify needs, test and codevelop, finance and ultimately buy solutions through the Minerals Council and/or Mandela Mining Precinct (*Also applicable to Goal*).

• **Goal 8** Assist organisations such as TIA to re-evaluate IP terms to be predictable and incentivising for start-ups.

#### Goal 9 Collective Approach

- Leverage the high resource availability for commodities of the future to develop a strong export market to the rest of Africa as well as globally.
- Minerals Council to inform local industry about existing and emergent standards, and engage with industry to push South Africa to lead the formulation of global mining standards.
- South Africa can lead global discourse and practices around
- people-centricity due to its long history and experience in mining health and safety.
- Get sector alignment on the purpose and potential impact of people-centred and technology-enabled modernisation.

## THREATS

#### **Goal 1** Building Human Capital

• New uses for platinum may come too slowly to fill the gap; equally, the energy transition from coal to renewables may create a gap in job creation

#### **Goal 3** Supportive Markets and Infrastructure

• Deteriorating energy and transport infrastructure resulting from government inactivity causes an existential threat to mining houses.

#### **Goal 4** Policies and Regulations

- Unpredictable legislation and governance that is unsupportive of industry and lacks transparent reasoning is perceived as too high a risk for international investment.
- Some state entities have limited collaborative processes, restricting engagements to improve internal processes and finance mechanisms.

#### Goal 5 Innovation Culture

• While other mining jurisdictions consider automation an opportunity, it is propagated as a threat by many in South Africa.

#### **Goal 6** Networking Assets

• If South Africa is unsuccessful in collaborating to develop the mining innovation ecosystem, they will likely be overtaken by international players.

#### Goal 9 Collective Approach

• Slow progress in developing the innovation ecosystem Impacts negatively on local and international competitiveness

# Stakeholder Mapping

Million



## **Overview of mining innovation ecosystem actors**

Market facilitators and intermediaries	Convenors and industry associations	19+	<b>Government and Regulatory bodies</b> consider the overarching societal and national needs and inform the direction of innovation. They also help set expectations and regulatory frameworks.	
Government	Public sector (regulatory bodies, collaborators)	9+	<b>Convenors and industry associations</b> provide a strategic view and a collective, coordinated and purpose-oriented approach to innovation. Both inform and, in many cases, help fund innovation efforts at the industry level.	
Professionals (Human Capital)	Training related services	6+	<b>Training related services and organised labour</b> provide critical input to direction setting, from the point of view of workforce, and skills needs. Skills transition is a core	
Civil society organisations	Organised labour	5+	consideration as the industry innovates, and training related services must remain involved and adjust skills development strategies to the needs of the industry.	
Research institutes	Academia and Research organisations	15+		
	R&D institutes	5+	<b>Academia, R&amp;D institutes, Finance, and incubators and accelerators</b> create or support in the creation of knowledge and value, by addressing the early to mid stages of technology development. They are the central players of the innovation ecosystem.	
Finance*	Finance	28+	*NOTE: Finance institutions in the IDIA Framework include angel investors, private equity, venture capitalist and developmental agencies	
Incubators and accelerators	Incubators and accelerators	4+		
	Advisory services	36+	Advisory services and supporting technology developers play a role both in the	
Private companies,	Supporting technology developers	16+	process of scaling and commercialising innovations to practical roll out.	
and enterprise	Original equipment manufacturers (OEMs)	63+	<b>OEMs</b> are critical to scale up innovations to the commercialisation stage. They create tools, and jobs.	
	Mining companies 84+		Mining houses are primarily involved in implementation and use of innovations. However, mining houses are also involved in investing and informing innovation-related strategy.	
IDIA Categorisation	Mining industry specific categorisati	on		



## Innovation stakeholder role analysis - key stakeholders driving innovation

Stakeholders interact with and impact the innovation ecosystem in different ways, depending on their role in scaling technology



**CSIR** plays an ecosystem development role with various partners to address the gap between R&D and proof of concept and scaling. It also provides advisory services and is often tasked with delivering innovation outputs. However, discussions with the iTeam indicate the need to strengthen their profile. **Minerals Council South Africa** (Minerals Council) is a major ecosystem developer and, through its partnerships, funds and delivers innovation outputs and advises the industry on important modernisation considerations. **Mandela Mining Precinct** (MMP) is a Public-private partnership between the Minerals Council and Department of Science and Innovation (DSI), aimed at steering the ecosystem in Extraction, Digitisation & People-centricity. **MHSC** facilitates tripartite engagements with the state, employers, and labour unions, while also funding research initiatives to improve occupational health and safety legislation and research outcomes.



Stakeholders interact with and impact the innovation ecosystem in different ways, depending on their role in scaling technology



The interactive map depicting Innovation stakeholder role analysis and relationships can be found using the following link: Interactive Mining Ecosystem Map

**KEY** • Convenor

Finance/VCs

Supporting Tech Dev. OEMs

Public Sector

Incubators / accelerators

- Academia/Research/R&D
- Advisory services
- Mining Companies

# Analysis of the Evolving Performance of the Mining Innovation Ecosystem



Goal 1 Building human capital



Although industry has seen a slight increase in graduate uptake, there is still a gap between the level of skills required by industry versus the quality of skills graduates possess when entering the market.

South Africa is getting better at leveraging their human capital and establishing a workforce that meets the demands of competitive economies. This is evident through South Africa's improved Human Capital Index, which moved from 92nd out of 124 countries in 2015 to 61st out of 137 countries in 2018<sup>1</sup>. However, only a slight increase is seen in the graduation rates, research outputs, and market uptake of graduates within the mining industry.

Before 2017 only 25% of students in the 20-24 age range were enrolled in full or part-time studies1. Of that, less than 20% were studying STEM-related and mining-related qualifications, which is relatively low compared to countries such as Canada and Australia, which have similar mining innovation climates. Since then, there have not been significant changes to graduation rates. However, there has been a noticeable improvement in the global rankings of universities that offer mining-related qualifications, with Wits ranking 15th and the University of Pretoria ranking 33rd.<sup>2.3</sup> Despite this improvement, the industry still feels that graduates do not possess sufficient skills.

The quantity of South African published research outputs in reputable journals, and the number of citations has grown over the past decade, with an ~8% annual increase in publications since 2015<sup>6</sup>. The primary driver of the growth has been the implementation of the Research Outputs Policy, which was revised in 2016 to allow for an increased weighting of book publication units and the inclusion of additional journal indexes<sup>6</sup>. On the other hand, patent applications have decreased in all sectors except health and digital<sup>7,8</sup>. This can be attributed to institutions and organisations becoming more "IP savvy" and opting for more cost-effective and efficient mechanisms to register IP and may suggest that the number of patent applications is no longer an adequate metric to assess the rate of innovation.

The industry also has a low retention rate (approximately 15%), with most graduates moving into other sectors like banking and consulting<sup>11,12</sup>. Despite many mining companies offering graduate and internship programmes, the opportunity remains for key ecosystem actors, like Wits Mining Institute, MMP and CSIR, to continue understanding skills development in similar ways to the CSIR capability and capacity assessment.

Goal 2 Access to finance



There has been an increase in RD&I expenditure from established mining companies, however, access to finance for SMMEs and new exploration ventures is still insufficient.

Government funding for R&D has more than doubled in the past decade. Despite this, total R&D expenditure in South Africa has steadily decreased since 2017, primarily due to a significant decrease in business-funded R&D.<sup>16</sup> Furthermore, access to capital for SMMEs and new innovative ventures in the mining sector has been severely restricted due to the risk-averse nature of investors, along with tax and regulatory policies or practices that deter investors from investing in SMMEs and start-ups.<sup>20</sup>

The HSRC notes that, in 2019, the total R&D expenditure in South Africa was R34.5billion, with government accounting for 58% (R19.4-billion), business 28% (R9.4-billion) and foreign companies and countries 14% (R4.7-billion) of the total. Mining R&D expenditure dropped by 44%, from R1.748-billion in 2018 to R686-million in 2019. This was attributed to the sale of mining companies and their assets or restructuring in R&D performing mining entities. In 2022, The HSRC in collaboration with the Minerals Council, will conduct a more detailed investment analysis for RD&I across the South African mining value chain.<sup>16</sup>

There is a need for more diverse and innovative funding mechanisms that accommodate SMMEs and emerging mining exploration companies. Early-stage high-risk ventures are mostly funded through venture capital (VC) investments.<sup>20</sup> The total number of VC deals (across all sectors) increased significantly from 2016-2020. However, SAVCA notes that, in 2020, less than 1% of these VC deals went towards the mining sector.<sup>16</sup> Moreover, in South Africa, since 2017, stream financing (whereby a streaming company makes an upfront payment to a resource company in return for the right to purchase a fixed percentage of future production) has gained traction as an alternative to debt financing from banks.<sup>19</sup>

The Fraser Institute survey for mining companies, in 2021, noted that the South Africa's investment attractiveness index had fallen substantially from its 2017 score.<sup>22,24</sup> Considering both policy and mineral potential in the investment attractive index, South African ranks in the bottom ten as one of the least attractive jurisdictions in the world, perpetuating the limited access to finance for the mining sector.<sup>24</sup>





**Goal 3** Supportive markets and infrastructure



Mining houses and OEMs have a high potential to access global markets, however increasingly dilapidated infrastructure is a significant threat to industry.

South African mining companies and OEMs have a high potential to access global and African markets, and opportunities exist for junior and emerging miners in critical minerals of the future. The development of infrastructure to strengthen the potential to export can further assist in accessing international markets. However, market access to the domestic supply chain remains challenging for SMMEs due to a lack of finance and other supporting mechanisms to break into the mining supply chain. Although, a number of initiatives do exist to diversify the mining supply chain, such as the ESD marketplace launched by the DMRE, Accenture and Adapt Digital Solutions Platform<sup>31,32</sup>.

There is also a high level of collaboration between R&D and research stakeholders. As an example, the research networks and relationships that exist through SAMERDI programmes provide an opportunity to better understand barriers to market access.

New infrastructure developments, such as the signing of the MoU between MMP and the Royal Bafokeng to operationalise the underground test mine, have the potential to significantly boost innovation<sup>27</sup>. However, there are many areas where infrastructure is failing, which poses a significant threat to the mining industry. Mining depends significantly on the government for water, energy, transport and housing (of employees). Since 2017, increasingly dilapidated energy and transport infrastructure resulting from government inactivity, together with the limitations on the ability of mining companies to build infrastructure to compensate for these failures, have caused a substantial existential threat to the mining sector<sup>25,26,28</sup>. The Presidential plan to address the energy crisis looks to create opportunities for innovation, particularly in renewable energy. The White Paper on National Rail Policy (2022) will also enable third-party access to Transnet's freight rail, and aims to remove bottlenecks and reduce the cost of transportation. However, many challenges remain in its implementation<sup>27</sup>.

#### **Goal 4** Policies and regulations



Constant regulatory shifts and poor innovation incentives impacts the level of innovation in the industry.

South Africa's policy landscape is constantly shifting, and industry regularly engages with policy amendments and creation. As a result, companies are forced to allocate additional resources to navigate the inevitable impact on their internal operations<sup>34 35</sup>.

The implementation of generic regulations, such as the Carbon Tax, does not consider the unique issues within the mining industry and acts as a disincentive to innovate<sup>36</sup>. However, over the last few years, there has been a notable shift in inclusivity in industry bodies tasked with developing regulations<sup>37</sup>. MHSC, for example, has an innovative process for developing policies and regulations. - this process is consultative and leverages technical expertise provide by mining companies. This is a shift from, for example, the challenges faced in the consultation process in the 2017 changes to the Mining Charter38. In addition, there have been several policy developments regarding intellectual property over the last 5 years. The first phase of the IP Policy is aimed at promoting localisation, utilising and preserving the country's resources, encouraging innovation, and empowering the domestic stakeholders to take advantage of the IP system<sup>39</sup>. However, whilst the introduction of the policy is a positive step forward the impact is yet to be seen, with low local content in manufacturing industries across South Africa and falling patent registration numbers<sup>40</sup>.

Although an innovation tax incentives exists in South Africa, there have never been incentives specific to the mining industry in South Africa<sup>41</sup>. However, the mining industry is still able to benefit from income tax incentives such as 12I as well as 11D from the R&D section of the Tax Act. Many of the larger mining companies have found success in accessing the 11D incentive to support their innovation initiatives. Accessing this incentive can be difficult for smaller companies<sup>42</sup>. To ensure that the incentives available work for the industry, Minerals Council South Africa has been and continues to work to advocate for industry-led changes to certain incentives<sup>38</sup>. Further to this, a decrease in the tax rate (from 28% to 27%) effective from March 31, 2023, is a benefit to individual mining houses and has the potential to support increased levels of innovation if savings are directed towards R&D budgets.<sup>36 42</sup>





#### Goal 5 Innovation culture

2017 2022

There is a positive trend in the growth of innovation culture within mining organisations.

The Minerals Council Modernisation Partnership with RIIS (established in 2017) has primarily helped the mining industry shift its understanding and perception of innovation. Before 2017, innovation was almost exclusively based on tangible technological outputs,<sup>52</sup> and organisations did not incorporate unique processes (e.g., collaborative policy development processes) under the umbrella of innovation. In recent years, increasing pressures given global changes, good and bad, have motivated companies to realise that change is required on various levels of operation.<sup>53</sup>

R&D intensity is a valuable metric to gauge how much a country values innovation. South Africa's R&D intensity declined by seven basis points, from 0,69% in 2018/19 to 0,62% in 2019/20.<sup>57,58</sup> The decline in R&D intensity could be an artefact of the pandemic, resulting from the limited access to laboratory facilities and a decrease in R&D expenditure from budget restrictions.<sup>58</sup> It is worth noting that, South Africa's R&D intensity is significantly lower than both Australia (1.83%) and Canada (1.70%) which are both global leaders in the mining sector.<sup>59</sup>

Relative to other middle-income economies, South Africa's total early-stage entrepreneurial activity (TEA) rate is very low. The TEA rate rose gradually from 7% in 2014 to 11% in 2017 and then declined slightly to 10,8% in 2019.<sup>54</sup> South Africa's low TEA rate indicates that there is a low motivation to start new businesses and demonstrates a negative perception of innovation and risk-taking. Furthermore, in 2019, South Africa's National Entrepreneurship Context Index (NECI) score was amongst the lowest, with a ranking of 49 out of 54 economies measured which indicates that South Africa's economic environment does not sufficiently support entrepreneurship.<sup>54</sup> The mining sector has, however, put initiatives in place, since 2017, to help drive innovation and entrepreneurship. The most notable of these initiatives are the Digital Mining Incubator at the Tshimologong Precinct and the Isidingo Drill Design Challenge.<sup>55,56</sup> **Goal 6** Networking assets



Industry has seen and improvement in networking and collaboration.

South Africa has a well-developed innovation culture which has grown over the last 10 years, with a clear shift in government policy and interest toward the 4IR, and subsequent support and funding for the development of various innovation and technology hubs<sup>60</sup>. This has led to increasing levels of support for SMMEs and start-ups through these accelerators and hubs, albeit with a limited specific focus on the mining value chain<sup>61</sup>. This increasing support available to new and small-scale enterprises is an important factor in ensuring the entrepreneurial pipeline is adequately developed and the mining supply chain remains competitive<sup>60 62</sup>.

Whilst there is increasing support available to SMME's, support for later-stage entrepreneurs and larger firms is less prevalent, with many larger entities forced to rely on existing tax incentives, small-scale government grants, and support systems that have been developed internally<sup>60</sup>.

It is important to note that increasing collaboration and networking of assets has the potential to support all ecosystem actors (both small and large-scale) to achieve their ultimate purpose and ensure that there is a real benefit to the industry (this includes, for example, universities seeking to build innovation talent; angel investors and VCs seeking investment opportunities, and larger organisations searching for solutions to seemingly intractable development challenges)<sup>63 64</sup>.

The networking of assets and degree of collaboration in the South African mining industry has significantly developed over the last few years, with a strong network of business associations and convenors that support the development of the industry. The facilitation of these networks and collaboration in R&D in mining is centralised, with most R&D activity in South Africa's mining sector geographically clustered in Gauteng<sup>64 65</sup>. Since 2018, for example, collaboration networks and relationships have been centralised in the MMP, whose strategic objectives aim to create sustainable and vibrant RD&I networks between industry, academic and science councils. However, MMP is still working on expanding its network of collaborators and has undertaken to review its strategy in light of current trends and stakeholder requirements to ensure alignment and beneficial collaboration activities<sup>61 64 65</sup>.





Goal 7 Equitable and inclusive participation



The openness of most mining companies towards equitable and inclusive participation has led to an improvement in innovation culture, however further work needs to be done.

Significant efforts have gone into improving inclusive and equitable participation in mining. Gender equality and social inclusion has improved, with the percentage of women making up the mining labour force growing from 10.5% in 2015 to 14% in 2022<sup>71,72</sup>. Initiatives such as the Women in Mining South Africa (WiMSA), advocates for women in the industry, while also providing them with a networking and mentoring platform, however, it is the only one of its kind since its establishment in 2010<sup>73</sup>. Efforts to include participation extend to other marginalised groups, such as people with disabilities through initiatives such as the MQA's Disability and Reasonable Accommodation Toolkit<sup>74</sup>. However, the industry is still struggling to meet the suggested disability quota due to the nature of the type of work done; nonetheless, the industry has noted a compound annual increase of 0.7% in employment of people with disabilities<sup>75</sup>.

Many organisations have put in place strategies to increase inclusive participation; however, their impact has been limited due to there not being any clear pipeline to collaboratively address such issues within the sector. The experiences shared at the Minerals Council's annual Women in Mining Catch-up Forum and Rio Tinto Workplace Culture study (released Jan, 2022) indicate that about 30% of women have experienced sexual harassment in the workplace and that racism is still a significant challenge for employees at many locations<sup>77</sup>. Furthermore, in 2018, the revised Mining Charter was published to address issues of inequality within the industry<sup>75</sup> but unfortunately there has been some challenges in effectively implementing some strategies relating to BBBEE and other social inequalities.

Openness to equitable and inclusive participation is linked to increased innovation uptake. The greatest improvements within the mining sector relate to mining health and safety. Initiatives by the MOSH Learning Hub, MMP's Isidingo Drill Design Challenge, and the Rock Hazard Identification and Safe Removal Challenge that was spearheaded by the Minerals Council in partnership with RIIS have benefitted the mining industry. The SATCAP programme has also positively contributed to people-centric modernisation in the industry, through various projects that have been piloted at a couple of "champion mines"<sup>80</sup>.

The outcomes of the discussion with the Minerals Council member innovation heads and champions, depicted below, indicate a strong positive correlation between the prioritisation of equitable and inclusive participation and the increase in the adoption of innovation within mining companies.



My company prioritises equitable and inclusive participation





#### Goal 8 Pathways to scale

Mining technology teams typically prioritise improved internal company processes for

There has been limited support specifically targeted at scaling of innovations in South Africa<sup>81</sup>. Whilst government scaling incentive programmes have been established, many of these programmes are difficult to access due to a lack of clarity on rules and regulations, while administrative processes remain slow and inefficient<sup>82</sup>. Nongovernmental support for scaling (such a VC funding) has grown over the years. however, a heavy focus on Cape Town and Johannesburg remains. In addition, there is a high threshold for scaling innovations within the local market, this is mainly due to the implementation of international benchmarking of innovations, which in some cases means that innovations which may be useful for the local market are disregarded because they do not meet international standards. As such, a better understanding of local market demands is required by funding organisations, like TIA for example. This is a perpetual issue faced by those developing innovations locally, and little change has been seen over the last decade<sup>83</sup>.

Networks of collaboration between key scaling actors in the ecosystem (such as accelerators and incubators) are beginning to form, however, these relationships are still in their infancy and coordinated efforts between entities (particularly incubators) that significantly impact the innovation scaling pathway are still growing<sup>84</sup>. Organisations such as the MMP, which officially opened in 2018, are supporting these efforts. These networks of collaboration have not vet developed to the point where they could impact the optimisation of the scaling pathway for innovations in the South African mining ecosystem however, whilst other actors, such as the Technology Transfer Offices have failed to achieve their intended outcomes, and collaborations to support scaling are virtually non-existent<sup>85</sup>.

Despite the successes seen from the increased focus on innovation and providing guidance on the adoption of technologies and leading practices given to industry through programmes, such as MOSH (focused on the adoption of leading practices to address health and safety concerns) and SATCAP (focused on people-centric technology adoption), some resistance to change remains within the mining ecosystem and market adoption timelines are lengthy, which hampers scaling<sup>86 87</sup>.

A review with the Minerals Council members innovation leads and champions indicates that many internal company considerations, such as internal budget and leadership approval and buy in, as well as internal company approaches or attitudes towards external funding sources (i.e., incentives) and collaboration to support innovation, as opposed to the actual innovation content, are most relevant for companies to scale innovation.

#### What needs are most relevant for my company to scale innovation?







**Goal 9** Collective approach to a developmental challenge



There is an increasing people-centered approach and collaboration to address development challenges.

There is strong consensus in the industry that innovation must be people-centred and technology enabled. People-centered innovation prioritises the Zero Harm imperative, environmental sustainability, economic development, and the competitiveness of the industry<sup>89</sup>. As a result, most R&D efforts focus on ESG, health and safety, 4IR, process optimisation, and the energy transition. At the same time, critical minerals have been identified as an opportunity area to broaden South Africa's commodity offering and strengthen the mining sector<sup>90</sup>. Numerous initiatives have been implemented and strategies developed by industry to collectively address these developmental challenges. Several universities aim to reduce youth unemployment by providing the relevant skills and technology. The WITs Mining Institute, for instance, provides a platform for development of new technology and ESG framework. It is also forms part of the SAMERDI network. Additionally, some synergies exist between the research areas.

Overall, the mining sector has well-established relationships and systems to enable collaboration on industry-specific development challenges. The Minerals Councils Modernisation Focused Strategy and partnership with RIIS has established platforms to engage on and investigate topics relating to people centred modernisation. The initiatives include the Mining Skills 4.0, Mpumalanga Coalfields 2030+, and Data 4.0. Four SAMERDI research centres, which expect to create new knowledge in different strategic mining focus areas in South Africa, have been established at the universities of Pretoria, Johannesburg and the Witwatersrand, with one to be launched at the University of the Free State <sup>92,93,94</sup>. The SAMERDI programme also has partnerships with a number of international universities. The CEO Zero Harm Forum and MHSC are key convenors collaborating with public and private entities on health and Safety <sup>92</sup>. Additionally, ICMM member companies, through the ICMM, position on Partnerships for Development (2011), have committed to developing and fostering partnerships which aim to enhance socio-economic development<sup>91</sup>.



# International Comparison



Stakeholders interact with and impact the innovation ecosystem in different ways, depending on their role in scaling technology





Stakeholders interact with and impact the innovation ecosystem in different ways, depending on their role in scaling technology





Stakeholders interact with and impact the innovation ecosystem in different ways, depending on their role in scaling technology





## Overview of the innovation ecosystem in the global context

environmentally friendly mining practices.

Europe is gradually shifting away from mining and towards earlier and later-stage processes. Russia Due to economic sanctions, Russian mining This includes increasing levels of R&D around companies continue to struggle to attract supporting technology development and R&D international finance. ш regarding processing or alternative uses of natural resources. Canada's well-developed mining innovation ecosystem; ranks high in investment Through regulatory reform and continued Canada China attractiveness with a public policy framework economic expansion, China is working to supporting mineral development. Worldposition itself as a leader in technology. investment, and production in the mining leading social and environmental practices, R&D efforts, geoscience knowledge and industry. education systems support the industry. States Mining in the United States is small relative to its other industries. However, the country has R&D in India is primarily conducted by Inid an enabling policy climate and a combination of OEMs - as such, the innovation ecosystem is United marketing and financial power contributing to underdeveloped, and the industry suffers. its perceived large mining footprint. Chile has high levels of natural resources. Although government involvement has Australia Australia has a developed mining innovation Chile impacted international investment, government ecosystem that has invested heavily in and local industry continue to prioritise R&D and is driving collaborations in local innovation to ensure the industry's future-focused areas such as automation. sustainability through various industry convenors and innovation initiatives. Brazil's mining industry contributes significantly South Africa has an underdeveloped Afrcia to GDP and employment in the country. Whilst mining innovation ecosystem. Although the ecosystem is still developing, significant well-developed networks and partnerships regulatory reforms have supported the exist for collaboration, inefficient policy and industry in achieving increased productivity, South public sector processes delay innovation. safety, and innovation. This shift has, in turn, Extensive development of infrastructure, necessitated an increased focus on and support scaling capabilities and financing for innovation to enable safer and more

mechanisms are required.



## A few players have a significant influence on the international mining ecosystem

In the global mining context, five major international companies have a considerable global influence: Glencore PLC, BHP Group Ltd., Rio Tinto PLC, Vale SA and Anglo American PLC. Although headquartered in particular regions (for example, Vale is headquartered in Rio de Janeiro, Brazil and BHP in Melbourne, Australia etc.), their operations are distributed across multiple jurisdictions worldwide.

The International Council on Mining and Metals (ICMM), headquartered in London, is a notable leadership organisation characterised as a worldwide leader in ESG practices, with a drive towards enabling sustainable development within the mining and metals industry. ICMM comprises 26 members, many of whom have a significant footprint within the global mining sector. Another notable international mining body is the Global Mining Standards and Guidelines Group (GMSG). GMSG facilitates improvement in safety and productivity by advancing standards and guidelines within the mining industry.

Regarding market capitalisation, BHP Group Ltd. leads the pack with an estimated market cap of US \$137.2 billion. However, Glencore PLC is far ahead when considering twelve-month trailing (TTM) revenues, with a TTM revenue of \$178.6 billion, as of September 2022.

The role that these stakeholders play along the global technology and innovation scaling pathway is depicted below.





## Canada - A global leader in mineral exploration and sustainable mining

Canada's mining innovation ecosystem is well developed, largely due to the country's significant RD&I expenditure, investor attractiveness, and access to finance for new mining ventures and mineral exploration.



#### **Country dynamics**

The Canadian minerals sector has a healthy business and innovation environment and consistently ranks among the top mining jurisdictions in investment attractiveness.<sup>85,86</sup> The industry is supported by intense R&D efforts, world-class geoscience knowledge and education systems; a public policy framework that supports responsible mineral development; a skilled labour force; and a wide array of funding instruments supporting innovation.<sup>85</sup> Moreover, the PDAC convention, hosted annually in Toronto, provides a platform for education and networking for stakeholders (including junior miners).<sup>87</sup>

The production of many of their key commodities is among the least carbon-intensive globally, due to the widespread adoption of renewable energy sources and the electrification of mining equipment and vehicle fleets.<sup>85</sup> The Mining Association of Canada's (MAC) Towards Sustainable Mining (TSM) initiative has been the main driver of sustainable mining practices in Canada and has consequently fuelled RD&I within the sector. This initiative has become a global leading practice in the improvement of performance on ESG issues.<sup>88</sup>

#### **Key organisations**

The mining innovation ecosystem in Canada is a complex system consisting of a wide array of stakeholders. Multiple convenors (CMIC, CEMI, IMII, COSIA and MAC), acting as neutral third-party intermediaries, have been established to coordinate research, development, and innovation efforts between various stakeholders. The most notable of these organisations is MAC - whose focus is on influencing policy within the sector, and CMIC - composed of major mining houses, CTOs and tech groups in Canada.<sup>89,90</sup> CMIC has also developed a global influence, with members in Australia and Europe.<sup>90</sup> The NRC is a government/semi-private research agency that does academic and research work. Additionally, venture capital firms such as Chrysalix, BDC, and the newly established Rethink Mining Ventures (a subsidiary of CMIC) have dedicated funds for investments into mining start-ups.<sup>91</sup>



#### **Lessons for South Africa**

South Africa should look to implement mechanisms to raise capital for new mining exploration ventures. Canada is a leader in worldwide exploration. In 2021, mineral exploration and deposit appraisal expenditures amounted to \$3.6 billion.<sup>86</sup> In contrast, South Africa's mineral exploration and deposit appraisal expenditures are relatively low, and the country still has a significant number of unexploited mineral reserves. The Toronto Stock Exchange (TSX) and TSX Venture Exchange (TSXV) are the world's number one mining and exploration listing venues, where 34% (\$10 billion) of the world's total equity capital was raised in 2021.<sup>86</sup>

South Africa should also look towards implementing an initiative similar to TSM, to ensure mining companies manage key environmental and social risks more effectively and take accountability for their ESG commitments, through the investment into supporting RD&I initiatives.



## United States - Shifting towards independent production of critical minerals for sustained national security

The US mining industry is relatively small but has an enabling policy climate. A combination of marketing and financial power contributes towards the country's perceived large mining footprint.



#### **Country dynamics**

Despite being one of the largest economies in the world, the United States mining sector does not contribute significantly to the country's overall GDP.<sup>92</sup> This is largely attributed to its dependence on imports for most of its critical minerals.<sup>93</sup> In 2020, Executive Order 13953 was issued, which aimed to expand local mining operations for these critical minerals, to reduce America's dependency on Chinese imports.<sup>93</sup> Similarly, attempts to reduce dependence on oil and gas imports from the Middle East (due to security concerns) led to the US becoming a global leader in oil and natural gas production.94 This was largely the result of the shale fracking revolution and the implementation of innovative oilfield technologies that have allowed producers access to new, unconventional shale resources.

#### **Key organisations**

The US Minerals Council, unlike South Africa's, does not have much influence on the national mining industry. There are only two large mining houses based in the US, namely: Newmont (the world's largest gold mining cooperation based in Colorado) and Freeport (the world's largest privately-owned copper mining company based in Phoenix, Arizona).<sup>95,96</sup> Prospect Mining Studio enables innovative teams to build, pilot, and scale solutions that drive enhanced sustainability and operational efficiency and bring innovation from industries adjacent to mining sector.<sup>97</sup> OEMs like Komatsu Joy and Caterpillar are leading innovators in open-pit mining, while General Electric and IBM play a key role in assisting the industry's shift towards mechanisation and applied AI technologies for downstream applications.

#### **Lessons for South Africa**



Although multiple initiatives are already in place to address bureaucratic inefficiencies, including the establishment of the Red Tape Reduction (RTR) task team and the DMRE policy review,<sup>98,99</sup> South Africa should seek to continually improve on the onerous regulatory environment, high taxation levels and poor infrastructure which contribute to its low investor attractiveness ranking. The United States has four mining jurisdictions ranked in the top 10 in global investment attractiveness.<sup>100</sup> Their high investment attractiveness ranking can largely be attributed to policy factors such as an efficient regulatory environment, moderate taxation levels, and high-quality infrastructure.<sup>100</sup> Similarly, South Africa should also leverage its capabilities to increase foreign investment into the local mining sector.



## **Europe - Fostering innovation through broad inter and intra country collaboration networks**

Parts of Europe have successfully shifted their role along the mining value chain and technology scaling pathway to ensure ongoing sustainability as mining in the region decreases.



#### **Country dynamics**

The mining ecosystem in Europe is gradually shifting away from mining and towards earlier and later-stage processes. i.e., increasing levels of R&D around supporting technology development and the processing or alternative uses of natural resources<sup>112</sup>. This shift has been supported by high levels of collaboration, both within and between countries<sup>113</sup>. The European Union and the collaborative political dynamics have partly enabled this. This collaboration enabled increased innovation levels and cemented Europe as a hub for technology development for the global mining industry<sup>115</sup>. In addition, mining and mining innovation across Europe is generally managed through enablement rather than hierarchy, allowing innovation to take place at all sector levels without requiring leadership to drive innovation<sup>116</sup>.

#### Key organisations

Key organisations operating across Europe include convenors such as EIT Raw Material, Euromines, and the ICMM (an international organisation with headquarters in London), VCs such as AP Ventures and the Anglo-American Sustainability Fund, as well as innovative mining-focused companies and initiatives such as RAG, and Swedish Mining Innovation, who work to support continued innovation within the mining industry and to ensure continued economic and environmental sustainability of mining regions in Europe<sup>117</sup><sup>118</sup><sup>119</sup><sup>120</sup>. In addition, many of these organisations partner with universities and private sector companies to further support innovation and R&D across the sectors. Several OEMs also drive innovation by providing finance and market access in the region; this includes companies such as Sandvik, Epiroc, ABB, Siemens, Schneider, Metso Outotec, FL Smidth and Tomra <sup>121</sup>.

#### **Lessons for South Africa**

South Africa can adopt a similar advocacy and collaboration role as the EU in supporting the mining industry to develop holistically. Leveraged correctly, this has the potential to enable resource-rich regions within SADC and AU to develop into global commodity suppliers, with South Africa as a leading technology provider.

The shift from extraction as a core focus in Europe to earlier and later-stage activities along the mining value chain has allowed many mining houses and suppliers to remain profitable despite decreased European mining activity. Future implementation of the requisite policies and enabling factors is an essential consideration for South Africa to allow for the shift in value offering.

Further to these lessons, an opportunity for South Africa is the potential to meet the EU's energy needs, particularly in light of the geo-political status of Russia at present.



## TOMRA



## Australia - Leaders in the implementation of technology-driven innovation and mining investment

Australia has a developed mining innovation ecosystem that has invested heavily in R&D and is driving collaborations in futurefocused areas such as automation.

#### **Country dynamics**

Australia is a global leader in mining R&D<sup>111,112</sup>. The Australian mining sector ranks in the top four industries for research and development investment in the country<sup>113,114</sup>. This results from the unprecedented rate at which innovation is embraced, with more than \$30 million (approximately R500 billion) invested in R&D since 2005<sup>114</sup>. It is also one of the top three nations for patent filings, with four of its universities ranked among the top five in the world regarding mining-related qualifications<sup>115,116</sup>.



R&D efforts in the Australian mining sector are supported by the Commonwealth Scientific and Industrial Research Organization (CSIRO), along with nearly 20 Cooperative Research Centers (CRCs) and several academic institutes, some of which have specialised mining-related research centres. A wide variety of organisations that support knowledge transfer, training, and exploration exist in addition to these research facilities. VCs such as BHP Ventures, Rio Tinto Ventures and RCF Jolimont also play a critical role in providing funding for mining and exploration-related projects. The Minerals Council of Australia (MCA) plays a leading role in identifying the critical future skills and the challenges surrounding them, while the mining companies and original equipment manufacturers (OEMs) are rising to the challenge to develop the necessary workforce of the future.

#### **Lessons for South Africa**

For most South African SMMEs, successful innovation initiatives have typically been carried out independently, with little to no engagement with mining companies and limited institutional support. Therefore, South African suppliers can better leverage and utilise coordinating agencies, research centres, and other industrial organisations, which help share the risk and cost for innovators, create communication spaces and systemically tackle common problems.





## Brazil - Innovation driven by worker safety and environmental impact concerns

Innovation is being driven by mining houses and conveners, to support an increased focus on improved safety and environmental performance.



#### **Country dynamics**

Brazil's mining industry contributes significantly to the country's GDP and employment, and whilst it cannot be considered as developed in the same way as countries such as Canada, there have been significant regulatory reforms. This includes active efforts to address corruption to support the industry in achieving increased productivity, safety, and innovation outputs<sup>128 129</sup>. Brazil's mining industry has undergone several changes over the last number of years, due in large part to the Mariana and Brumadinho dam failures (2015 and 2019, respectively)<sup>130 131</sup>. Inadequate enforcement of regulations, in part, caused both dam failures. These failures have seen industry stakeholders and the government taking a renewed approach to safety, environment, and community development<sup>132</sup>. This shift has, in turn, necessitated an increased focus on and support for innovation to enable safer and more environmentally friendly mining practices. Larger mining houses, such as Vale, have led these initiatives and provided supporting finance. In contrast, the government does not prioritise innovation and lacks funding and policy support to drive innovation<sup>133 134</sup>.

#### **Key organisations**

One of the key players in the Brazilian mining industry is the Brazilian Institute of Mining. This non-profit organisation represents companies and institutions operating in the mining sector and aims to encourage industry innovation<sup>135</sup>. Similarly, Mining Hub is an open innovation platform supporting collaboration and innovation to solve mining-related challenges<sup>136</sup>. Vale is the largest company in South America and the largest mining house in Brazil. Linked to Vale is Vale Ventures, a VC intended to support start-ups focused on developing disruptive innovations to address challenges in the mining and metals sector<sup>137</sup>.

Another key stakeholder is the National Mining Agency, established in 2017, to support the renewed effort to regulate the industry adequately<sup>138</sup>. CBMM, a Brazilian-owned mining house, is also a significant player in innovation, mining and developing products using Niobium, and drives and funds niobium-related innovation globally<sup>139</sup>. Finep is also a key innovation funding stakeholder<sup>140</sup>.



#### **Lessons for South Africa**

The regulatory issues and corruption that led to the dam disasters and other environmental degradation in Brazil are crucial considerations for South Africa. Stakeholders in the public and private should adopt a longer-term view to reduce the impact of high levels of corruption and regulatory uncertainty on the hampering that these have on innovation within the industry.



## Chile - Government and industry are prioritising innovation

Whilst the nationalisation of many of the larger mines has a negative impact on foreign investment to the regions, the government and local industry continue to prioritise local innovation to ensure the sustainability of the industry.



### **Country dynamics**

Whilst Chile has abundant natural resources (mainly lithium and copper), government ownership and involvement in the mining industry have impacted international investment. However, the government has, in recent years, actively worked to increase levels of foreign investment through investment protections and policy reform. However, the cyclical nature of the mining industry and the government is a hurdle for longer-term innovation<sup>141</sup>

Collaboration is evident across the sector, with mines supporting and funding the local development of innovations that enhance competitiveness<sup>143</sup> <sup>144</sup> <sup>145</sup>. The government's support, enabling policy and funding mechanism for collaboration are key innovation drivers<sup>146</sup>. As such, innovation to support the mining industry's sustainability in Chile has been prioritised over the last few years through various industry convenors and innovation initiatives<sup>147</sup>. Moreover, Chile has an abundance of human capital available for the mining industry, mainly sourced locally through several universities offering engineering and mining-related studies<sup>150</sup>.

#### **Key organisations**

Critical organisations within the industry include several industry-agnostic convenors, such as Mara Chile and Fundación Chile, as well as Expande Minería. Expande is a mining innovation-focused platform linked to Fundación Chile, which is working to enable collaboration on industry-wide challenges. They have found success with over 2300 solutions for mining challenges mapped and upwards of \$50 million in contracts and capital raising for suppliers<sup>151</sup>. The largest mining houses in the country include Codelco (a state-owned copper mining house) and SQM (a lithium mining company owned in part by the Chilean government)<sup>152 153</sup>. CORFO is also an important stakeholder and oversees programmes aimed at generating economic development through the promotion of inward investment and the advocacy of competitiveness for domestic companies<sup>154</sup>.



#### **Lessons for South Africa**

A key lesson for the South African mining industry, from the Chilean context, is the government's hyper-reactive policy shifts and the manner in which innovation is encouraged or supported, shifting from highly conservative, laissez faire approaches to industry, to overzealous and micromanagement style approach. This often has dire consequences for the industry and country at large.

The Mandela Mining Precinct may benefit from adopting a similar approach to Expande, which has succeeded through broader collaboration across industries enabled by its links to an industry-agnostic convenor. Similarly, the South African mining sector can leverage the relative strength of other manufacturing industries, such as automotive, chemicals, clothing and textiles.



## China - Industry expansion driven by government-led innovation

The success of the Chinese government in leading innovation within the country is a lesson for South African government agencies.

### **Country dynamics**

Through regulatory reform and continued economic expansion, China is working to position itself as a leader in technology, investment, and production in the mining industry<sup>155</sup>. The rapid growth in the sector is credited, in part, to low wages and global competitiveness, which have often had often been achieved with precarious work conditions and poor safety and environmental standards<sup>156 157 158</sup>. For example, China can underbid other manufacturers of Rare Earth Metals because of inadequate environmental standards.

The size of the mining industry, the downstream manufacturing industries, and the available capital can enable China to become a significant player throughout the value chain as a producer of minerals, supplier of supporting technologies and customer. The government generally leads R&D developments in mining and manufacturing value chains through funding and policy enablement<sup>159 160</sup>. Where the government does not lead innovation, however, there needs to be more foreign companies and support for local start-ups to innovate.

#### **Key organisations**

Some of the key stakeholders in the Chinese mining industry include the Ministry of Natural Resources and the National Mine Safety Administration, tasked with policy development and adherence, as well as the China Academy of Safety Sciences and Technology (CASST), which includes a mining-specific arm, and is involved in science and technology advancement and technological innovation relating to safety<sup>161 162 163</sup>. Many different mining houses are mining a host of natural resources. Zijin Mining is one example, a large multinational mining group engaged in the global exploration and development of copper, gold, zinc and lithium, as well as engineering and technological research<sup>164</sup>. Others include Jiangxi Copper, China Energy Investment Corporation, Yangzhou Coal Mining Company, China Coal Energy, and Zhaojin Mining Company, a gold mining company with high levels of innovation (although it is unclear if this innovation is done locally)<sup>165 166 167</sup>.





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South African government agencies, that are tasked with driving innovation, may learn from the Chinese government's successful implementation of appropriate supporting policies and funding mechanisms that have driven innovation across various industries. At the same time, the South African mining industry must employ strategies that drive industry increased levels of growth and economic development without destroying nature, health, and democratic freedom.



## India - Local innovation throughout the value chain is limited

R&D in India is conducted largely by OEMs – as such the innovation ecosystem is underdeveloped and the industry as a whole suffers.



#### **Country dynamics**

India has been undergoing significant regulatory reforms in regard to the mining sector, in an effort to increase participation of the private sector in mineral exploration and allow for more land to be made available to mine168. However, changing policies and rent extraction leads to foreign investors being hesitant to invest and local investors relocating where possible<sup>169</sup>. In addition, the mining conditions are generally very basic, and safety and worker health often has very low standards (this includes the processing sector which often has informal working conditions)<sup>170</sup>.

The large number of mining companies within the country tends to limit collaboration with high levels between companies mining the same resources (even within innovation). Further to this, R&D and innovation is often outsourced, generally through OEMs and, in some cases, science councils or universities (who focus primarily on research), although some of the larger companies have internal R&D capabilities<sup>171</sup>.

#### **Key organisations**

Key organisations include the Ministry of Mines and the Indian Bureau of Mines, who regulate the industry and control the state-owned mining houses<sup>172 173</sup>. A number of science councils and universities are engaged in R&D at various levels, these include the CSIR-IMMT, TEXMIN, Indian School of Mines, and the National Institute of Rock Mechanics<sup>174 175</sup>. The industry also has a number of convenors, including the Federation of Indian Mineral Industries, the main purpose of these convenors relates to policy reform and advocacy and innovation is not a priority focus<sup>176</sup>.

There are many mining houses located throughout India, most notably, two of the largest state-owned mining and exploration companies include the National Aluminium Company Limited and NMDC Limited, whilst two of the largest private mining houses include Vendata and Hindalco<sup>177 178 179</sup> <sup>180</sup>.



#### **Lessons for South Africa**

Shifting regulations and the impact of changing government policy, as well as rent extraction are a concern for local companies and foreign investors – a parallel to the South African industry. In some cases, it has led local Indian investors to relocate where possible, for example the biggest Indian steel companies are HQd in Europe. Locally produced innovation is limited in India and the burden of R&D rests on OEMs, with limited mining-sector specific support available for start-ups. In this regard, South Africa, while still requiring development, is shifting towards increased levels of support for innovators, both in terms of financing, and mentorship and technical support. As South Africa seeks to increase collaboration and networking in the mining sector, to support increased innovation, establishing an ecosystem where knowledge sharing without secret sharing is crucial. Looking at the negative impact this has in India is a lesson for South Africa to ensure adequate focus is placed on finding a solution to this issue.



## Russia - Innovation efforts centered mainly around security/defense, rather than any other sector

Due to economic sanctions, Russian mining companies continue to struggle to attract finance on international markets.

#### **Country dynamics**

A majority of Russia's government funding in scientific research goes towards military technologies, consequently leading to a lower focus on civilian and commercial application of emerging technologies in other sectors<sup>170</sup>. Additionally, the Russian government's limitations on property rights, along with the volatile market environment, has disincentivised a lot of investors from making the necessary venture capital investments required to transform places like Skolkovo into a leading hub of innovation and economic dynamism like Silicon Valley<sup>171,172</sup>. Russia also suffers from low human capital retention rates and current trends suggest that by 2030 Russians will account for less than 5% of the world's working-age college graduates, which is significantly lower than its international competitors, including the U.S. and China1<sup>70,173</sup>. The primary reason for this is because most highly educated Russians are opting to emigrate to other countries due to the geo-political issues of the country<sup>174,175</sup>.



#### **Key organisations**

Some of the key stakeholders in the Russian mining innovation ecosystem include the Russian National Committee of the World Petroleum Council which looks into the financial and management problems in the domestic oil and gas industry and assists in the development and application of scientific and technological achievements<sup>176</sup>. The Skolkovo Innovation Center is a high technology business area which is home to many tech start-ups such as RiT Automation and R&D units such as Digital Lab by Nornickel, which looks into the applicability of new technologies for the mining sector and tests them in production processes<sup>177</sup>. Other mining companies leading different innovation projects include Polyus, Severstal, Evraz and Rusal. With regards to academic institutes, Russia does not possess a lot of universities ranked highly for their mining-related qualifications but one that does stand out is Tomsk State University which has had a lot of cited publications released in recent years<sup>178</sup>.



#### Lessons for South Africa

Retaining talent should become a top priority for any economy looking to become a hub for innovation. Russia currently struggles with the "high education, low human capital" paradox1, in which they would need to strengthen their public policies that support training and education and encourages the retention of skilled workers through various forms of incentives. Therefore, for its finest and brightest minds, South Africa needs to provide a compelling value proposition that gives them the chance to hone, put to use, and benefit from their knowledge and abilities particularly within the mining industry, instead of moving into other sectors or migrating to other countries.

## Appendix 1 Detailed Goal Criteria for Analysis Developed from Global Leading Practice

Each ecosystem goal was characterized into categories using their respective challenges and strengthening strategies outlined in the IDIA framework.



		Goal 1 Bu	ilding human capital		
Graduation rates	Relevant degrees are not offered within the country (where ecosystem is growing)	Relevant degrees are offered at limited institutions	Relevant degrees are offered but there is no clear pipeline for careers relating to innovation and mining for graduates	Relevant degrees are offered and there is a clear pipeline for careers relating to innovation and mining for graduates	Relevant degrees are offered and there is a clear and efficient pipeline for careers relating to innovation and mining for graduates
Research outputs	<ul> <li>No publications in reputable, peer-reviewed journals</li> <li>No patents</li> </ul>	<ul> <li>Limited publications in reputable, peer-reviewed journals</li> <li>Limited or declining number of patents</li> </ul>	<ul> <li>Growing number of publications</li> <li>Growing number of patents</li> </ul>	<ul> <li>Consistently high research publication outputs</li> <li>Regular patents and established patenting and IP process within the country</li> </ul>	<ul> <li>High contribution to global, high citation rate</li> <li>Regular patents and established patenting and IP process within the country, when compared to rest of the world</li> </ul>
Market uptake of the graduates	No skills and diversity of skills in graduates entering the ecosystem	Limited skills and diversity of skills in graduates entering the ecosystem	Growing skills and diversity of skills in graduates entering the ecosystem	Good balance in number skills and diversity of skills in graduates entering the ecosystem	Good balance in number skills and diversity of skills in graduates entering the ecosystem; globally competitive skill sets
		Goal 2	Access to finance		
Range of funding institutions and diversity of funding mechanisms	No financial institutions and no diversity of financing mechanisms	<ul> <li>Limited number of institutions but insufficient to meet the needs of an innovation ecosystem.</li> <li>Limited diversity of funding mechanisms</li> </ul>	<ul> <li>Growing number of financial institutions</li> <li>Growing diversity of financial instruments</li> </ul>	<ul> <li>Wide range of institutions (VC, angel investors banks, PE etc)</li> <li>Diverse range of financing mechanisms being employed</li> </ul>	<ul> <li>Wide range of institutions (VC, angel investors banks, PE etc) - both in and outside South Africa</li> <li>Great diversity of innovative funding mechanisms being employed</li> </ul>
Investment attractiveness	Extremely low investment attractiveness score (bottom 5 ranking by Fraser institute) with no indication of improvement	Low investment attractiveness score (bottom 10 ranking by Fraser Institute) with some indication of improvement	Moderate investment attractiveness score with some indication of improvement	High investment attractiveness score (top 10 ranking by Fraser institute) with some indication of improvement	High investment attractiveness score (top 5 ranking by Fraser institute) with some indication of improvement
Criteria	Performance rating				



		Goal 3 Supportiv	e Markets and Infrastructure		
Infrastructure	No supporting infrastructure	Limited infrastructure that is inadequate	Expanding infrastructure with the availability of adequate infrastructure	Availability of high-quality infrastructure, with the uptake of infrastructure innovations	Availability of high-quality infrastructure, with high uptake and effective implementation of innovative infrastructure
Markets	No access to market	Limited access to market	Growing access to market	Innovators can easily access local market	Innovators can easily and fully access local markets and have opportunities to access international markets
Connections between R&D institutes	No collaboration between R&D and research stakeholders	Limited collaboration between R&D and research stakeholders	Growing collaboration between R&D and research stakeholders	High level of collaboration between R&D and research stakeholders with SA, with some international collaboration	High level of collaboration between R&D and research stakeholders in SA, with well-established pathways and systems for international collaboration and tech transfer
		Goal 4 Po	licies and regulation		
Tax incentives	No tax incentives	Limited tax incentives	Growing number of favourable tax incentives	Well established and favourable tax incentives with supporting governance processes and systems to support their implementation	Well-established and favourable tax incentives with fully functioning supporting governance processes and systems to support their implementation
Tax rates	No tax resulting in a lack of infrastructure development and poor innovation potential within the country	High tax rates with non-favourable tax legislations	Semi-favourable tax rates with developing tax legislations to help grow the SA innovation ecosystem	Favourable tax rates and supporting tax legislations within the South African innovation ecosystem	Favourable tax rates and supporting tax legislations that allow for international participation in the local innovation ecosystem
Criteria	Performance rating				



	$\bigcirc$				
		Goal 4 Polici	es and regulation (cont.)		
Patents	Complex and non-favourable IP and patent laws	Non-conducive systems for the allowance of new patents and IP	Growing number of favourable patent and IP laws with a limited number of governing bodies to manage them	Favourable laws and processes for registering IPs and patents	Streamlined processes for IP and patent registration
Regulations	Highly regulated with policies discouraging innovation / adoption of innovative practices	Regulated with policies discouraging innovation	Regulations shifting to support / encourage adoption of innovative solutions	Sector regulated effectively, encouraging the adoption of innovative solutions	Sector regulated effectively, encouraging local and international investment driving robust R&D and innovation commericailistion
		Goal 5 Nurturing a d	culture supportive of innovation		
Understanding	No understanding of the principles of innovation and its benefit to society	Limited understanding of the principles of innovation	Growing understanding of the principles of innovation	Complete understanding of the principles of innovation and limited adoption of innovation driven projects	Complete understanding of the principles of innovation and widespread adoption of innovation driven projects
Perception	Generally, a negative perception of innovation, risk taking, and the adoption of new tech and processes.	Mostly neutral / indifferent to the adoption of innovative tech and processes	Growing positive perception on the adoption of innovations	Highly positive perception of innovation and growing number of risk-taking innovators within the ecosystem	Highly positive perception of innovation with a thriving innovation culture and a continuous stream of risk- taking innovators into the ecosystem
R&D Intensity	Extremely low R&D intensity, relative to other developing nations, with significant YOY decline in R&D intensity	Low R&D intensity relative to other developing nations with a steady decline in R&D intensity over the past few years	R&D intensity on par with other developing nations with a steadily increasing/ consistent R&D intensity over the past few years	High R&D intensity relative to other developing nations with a steadily increasing/ consistent R&D intensity over the past few years	High R&D intensity relative to other developing and developed nations with a steady YoY increase in R&D intensity
Criteria	Performance rating				

43



	Goal 6 Supporting c	oordinated networking of assets	that enable productive collabor	ations between different actors	
Entrepreneur support (incubators, hubs accelerators)	No support	Limited support	Growing support	Well established support systems focusing on the sector and a strong pipeline of entrepreneurs	Well established support systems focusing on the sector and a strong pipeline of entrepreneurs with successful market penetration
Networks	No networks	Limited networks exist	Some strong networks exist, with limited diversity and limited industry convenors to facilitate access to them	Strong and diverse networks with well-established industry convenors to facilitate access to them	Strong and diverse, fully- utilised networks with well- established industry convenors to facilitate access to them
Degree of collaboration	Independent working and no cooperation between ecosystem actors	Limited cooperation between ecosystem actors	Growing cooperation / collaboration within the ecosystem	Well-established relationships and systems to enable collaboration within the ecosystem with long- term strategies to sustain collaboration	Well-established relationships and systems to enable collaboration within the ecosystem with long- term strategies to sustain collaboration, with local and international entities
	Goal 7 En	suring equitable and inclusive e	cosystem governance and partic	ipation infrastructure	
Gender equality and social inclusion in research and entrepreneurship	No diversity with no opportunities for marginalised groups	Limited diversity with limited opportunities for marginalised groups	Growing diversity with growing opportunities for marginalised groups	Diverse ecosystem with ample opportunities for marginalised groups at various TRLs	Diverse ecosystem with a wide range of consistent opportunities for the inclusion of marginalised groups at different TRLs
Addressing current social inequalities	Sector's innovation initiatives do not address and often exacerbate current inequalities	Limited focus on addressing inequalities and only at level of specific organisations	Growing focus on addressing inequalities by multiple actors	Strong collaborative efforts to address inequalities with the entire ecosystem	Strong collaborative efforts to address all existing inequalities within the entire ecosystem, using strategies that align with local transformation goals
Innovation uptake	No uptake of innovation ideas and processes across the sector	Limited uptake of innovation ideas and processes driven by only a few specific organisations within the ecosystem	Growing uptake of innovation ideas and processes	Widespread uptake and adoption of innovation ideas and processes across the different business maturity levels	Widespread and consistent uptake of innovation ideas and processes across the different business maturity levels
Criteria	Performance rating				



		Goal 8 Creating smoother pa	athways to scale for specific inno	vations	
Incentives to scale and enabling policies / regulations	No incentives	Limited incentives	Growing number of favourable incentives	Well established and favourable incentives with supporting governance processes and systems to support their implementation	Well-established and favourable incentives with fully functioning supporting governance processes and systems to support their implementation
Understanding of market needs (demand vs supply)	No alignment and communication between government, demand side and supply side actors in the innovation lifecycle	Limited alignment and communication between government, demand side and supply side actors in the innovation lifecycle	Growing understanding of the market with alignment [on market needs] and more frequent communication between government, demand-side and supply side actors in the innovation lifecycle	Well-established understanding of the market demand from all actors, with clear alignment between demand and supply side actors early in the innovation lifecycle	Well-established understanding of the market demand from all actors, with clear alignment between demand and supply side actors early in the innovation lifecycle with consistent evidence of innovation uptake scaling
Degree of collaboration* (same as goal 6, considered specifically for pathways to scale in this case)	Independent working and no cooperation between ecosystem actors	Limited cooperation between ecosystem actors	Growing cooperation / collaboration within the ecosystem	Well-established relationships and systems to enable collaboration within the ecosystem with long- term strategies to sustain collaboration	Well-established relationships and systems to enable collaboration within the ecosystem with long- term strategies to sustain collaboration, with local and international entities
	Goal 9	Mobilising a collective ecosyste	em to address a particular develo	pment challenge	
Awareness and agreement on development challenge	No awareness and agreement on development challenge	Limited awareness and agreement on development challenge	Growing awareness and agreement on development challenge	Clear awareness and agreement on development challenge	Clear awareness and agreement on development challenge with coordinated efforts to address the challenge
Collaboration on development challenge	(same as goals 6 and 8, considered specifically under the lens of "addressing a particular development change")				
Criteria	Performance rating				

Appendix 2 Detailed SA Mining Innovation Ecosystem Assessment



## **Goal 1** Building Human Capital

Research argues that sustainable development is only possible when human and social capital intervene and result in innovation ecosystems. Therefore, building human capital, which is the process of growing the knowledge, capacities, skills, relationships and expertise that enables people to innovate and support innovation processes, is critical to enable the increasing calls for greater local ownership of innovation, and the shift away from importing "expertise" and solutions from elsewhere.



LEGEND 2017 2022 MATURITY SCALE Non-existent Under-developed Developing Developed Fully-developed Score Descirpotion



## **Goal 2** Access to Finance

Lack of access to appropriate and sufficient finance remains one of the most important factors to address for productive and sustainable entrepreneurship. Strong entrepreneurial ecosystems need a multifaceted range of funding institutions to provide various financial products and services.





## **Goal 3** Supportive Markets and Infrastructure

Access to markets determines the access that innovative businesses have and the market opportunities that shape success or failure. In domestic markets, which are usually most relevant for entrepreneurs, the maturity of infrastructure supporting their functioning is critical.





## **Goal 4** Policies and Regulations

MATURITY SCALE Non-existent Under-developed

LEGEND

Policy and regulatory environments are powerful in determining how well innovation processes and actors operate. They can actively prohibit innovation through strict rules, high levels of risk adversity and institutional practices that encourage resistance to change.



Score Descirpotion

50



## **Goal 5** Nurturing a culture supportive of innovation

Contributions from a wide range of actors over a long time period are typically required to help nurture a positive culture of research and entrepreneurship feeding into innovation processes and where innovation can flourish.





## Goal 6 Supporting coordinated networking of assets

South Africa has a strong innovation culture and offers support for early-stage entrepreneurs. There is generally limited focus on developing start-ups with products that specifically address mining needs, and on later stage entrepreneurs. The facilitation of networks and collaboration in R&D is centralised, and based in Gauteng, with different entities focused on different processes. Work on expanding the network of collaborators is required.





## **Goal 7** Ensuring equitable and inclusive ecosystem governance and participation infrastructure

Ecosystem strengthening is the examination and interrogation of ecosystem strengthening work through an equity and inclusion lens. In practice, this requires a stronger focus on the process of strengthening initiatives as well as their outputs, in recognition of the concern that if we are not intentional about assessing how innovation is applied, we risk re-creating the inequalities of established systems.



Score Descirpotion

LEGEND

MATURITY SCALE Non-existent Under-developed

Developing Developed Fully-developed



## **Goal 8** Creating smoother pathways to scale for specific innovations

Lack of access to appropriate and sufficient finance remains one of the most important factors to address for productive and sustainable entrepreneurship. Strong entrepreneurial ecosystems need a multifaceted range of financial institutions to provide various financial products and services.







## **Goal 9** Mobilising a collective ecosystem to address a particular development challenge

Connecting and mobilising actors within a particular ecosystem provides opportunities to raise awareness of specific issues and gaps, share ideas and encourage participation and relationship-building among various actors, stakeholders and communities, identify institutional strengthening needs and enable the appreciation, use and uptake of innovation for a specific purpose or to address a complex problem.



There is a strong consensus in the industry that innovation must be people-centred and technology-enabled. People-centred modernisation prioritises the Zero Harm imperative, environmental sustainability, socio-economic development, and the competitiveness of the industry<sup>89,90</sup>. As a result, most R&D efforts focus on ESG, health and safety, 4IR, process optimisation, and the energy transition. At the same time, critical minerals have been identified as an opportunity area to broaden South Africa's commodity offering and strengthen the mining sector<sup>91</sup>.

ICMM member companies, through the 2011 Partnership for Development Position statement and toolkit, have also agreed to create and foster partnerships, which aim to contribute to the economy and enhance socio-economic development<sup>92</sup>. Since then, member companies in South Africa have further developed relationships through initiatives such as SAMERDI and through Minerals Council membership. ESG is also a priority area in the SAMERDI, CSIR and Wits Mining Institute strategies<sup>35,94,95</sup>. Extensive efforts have gone into improving mine health and safety, which is still a key R&D area for the CSIR, MHSC, Minerals Council, and the Mandela Mining Precinct.

Overall, the mining sector has well-established relationships and systems to enable collaboration on industry-specific development challenges. The Minerals Council's Modernisation Focused Strategy and partnership with RIIS have established platforms to engage on and investigate topics relating to people-centred modernisation. The initiatives include Mining Skills 4.0, Mpumalanga Coalfields 2030+, and Data 4.0. Four SAMERDI research centres, which expect to create new knowledge in different strategic mining focus areas in South Africa, have been established at the universities of Pretoria, Johannesburg and the Witwatersrand, with one to be launched at the University of the Free State<sup>93,94,95</sup>. The SAMERDI research focus areas are built on Mandela Mining Precinct thematic area. The Centres have established good partnerships, collaborating with UP, UCT, UJ, MMP, Sibanye Stillwater, Akita University (Japan), Minerals Council South Africa and the Lulea University of Technology (Sweden)<sup>93</sup>.

The SAMERDI programme also has partnerships with a number of international universities. The CEO Zero Harm Forum within the Minerals Council, and the tripartite entity MHSC are key convenors collaborating with public and private entities on health and Safety<sup>92</sup>. Additionally, ICMM member companies, through the ICMM position on Partnerships for Development (2011), have committed to developing and fostering partnerships which aim to enhance socio-economic development<sup>92</sup>.



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