Mining 2030

October 2024

# Landscape Report

## The Role of Investors in Realising an Environmentally and Socially Responsible Mining Industry

Report prepared for the Global Investor Commission on Mining 2030 by Chronos Sustainability Ltd



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# Introduction

The Global Investor Commission on Mining 2030 (the Commission) is a collaborative initiative with the mission to develop a consensus around the role of finance in realising the vision of a socially and environmentally responsible mining sector by 2030. It recognises the mining industry's important role in society and the transition to a low carbon economy, and aims to ensure the sector leaves a positive legacy by addressing key systemic risks holistically. A socially and environmentally responsible sector is understood as one that:

- Has a clear social license to operate;
- Can meet the needs of society in a responsible manner without driving conflict or corruption;
- Operates in a way that respects planetary boundaries; and
- Positively contributes to social development and the environment, today and tomorrow.

The Commission is investor-led. An investor Steering Committee oversees the operation of the Commission which operates on an advisory basis, and, together with an Investor Supporter Group, compiles the outcomes of the Commission deliberations. consolidates findings and will develop an action plan for adoption by the investor community.

Membership of the Commission is multi-stakeholder, including representatives from mining-affected communities, civil society, trade unions, companies and investors amongst others. The Commission is inspired by investors' response to the Brumadinho disaster. This resulted in wider company disclosures of their tailings facilities, a global industry standard developed together with industry and the UN, and the formation of an independent Global Institute to support the auditing of individual mines on their adherence to the Standard.

# About This Report

This report maps the current and projected future of the mining landscape, including the challenges, opportunities, and impacts of mining activities. The aim is to inform the development of the Commission's strategic objectives and priority actions.

The report is broken down into four chapters:

1. **Overview of the current mining landscape.** This includes current production volumes and geographies, how these are projected to evolve in the future, and the challenges and opportunities for the sector in meeting mineral demand.
2. **Impacts of the mining industry.** This includes analysis of the social and environmental impacts of the sector's activities.
3. **Investor role in shaping the mining sector.** This includes analysis of key stakeholders, relevant standards, and where investors can effect change within the mining value chain.
4. **Recommendations for investors.** This includes conclusions on key areas where collective investor action can realise a more socially and environmentally responsible mining sector.

The research for this report was conducted through a desk-based review. Relevant literature was identified through consultation with Commission members. This report has drawn mostly from publicly available professional, academic and technical sources, and unpublished resources provided by the Commission and Technical Advisory members.

The analysis and data in the report focuses on 17 minerals. These are shown in Table 0.1 listed under the five categories used in the annual World Mining Data publication.[1] The report is therefore not an exhaustive survey of all mining but prioritises those minerals with high levels of current and projected production and correspondingly significant social and environmental risks. The transition minerals highlighted refer to those considered necessary to deliver a low-carbon economy.[2,3]

| Category | Minerals in report scope (transition minerals in bold) | Minerals out of scope |
|---|---|---|
| **Iron and Ferro-Alloy Metals** | **Iron, Cobalt, Chromium, Manganese, Nickel, Vanadium.** | **Molybdenum, Niobium, Tantalum, Titanium, Tungsten** |
| **Non-Ferrous Metals** | **Bauxite, Copper, Lithium, Zinc, Silicon** | **Aluminium**, Antimony, **Arsenic**, Beryllium, Bismuth, **Cadmium**, **Gallium**, **Germanium**, **Indium**, **Lead**, Mercury, **Rare Earth Minerals**, Rhenium, **Selenium**, **Tellurium**, **Tin** |
| **Precious Metals** | Gold | Platinum-Group Metals (**Palladium**, **Platinum**, Rhodium), and **Silver**. |
| **Industrial Minerals** | **Graphite**, Gypsum, Phosphate Rock, metallurgical coal | Asbestos, Baryte, Bentonite, Boron Minerals, Diamond (Gem/Industrial), Diatomite, Feldspar, **Fluorspar**, Kaolin (China-Clay), Magnesite, Perlite, (incl. Guano), Potash, Salt, Sulphur, Talc (incl. Steatite and Pyrophyllite), Vermiculite, and Zircon. |
| **Mineral Fuels** | Thermal coal | **Uranium**. *(Note: lignite, uranium, natural gas, petroleum, oil sands, and oil shales can also be considered as 'mineral fuels' but as these are not mined goods, they are beyond the scope of this report).* |

*Table 1. Focus of the Report by Mineral Category*

# Executive Summary

**This far-reaching landscape report lays out the many positive and negative impacts of the mining sector and its fundamental role in the global economy and in the low carbon transition. Most importantly, it provides a direction of travel for investors to collectively address the sector's systemic risks from conflict to climate, and the need for a different approach by investors to the sector if it is to leave a positive legacy for host communities and the environment whilst meeting global demand. It calls for a reset by investors of their relationship with the industry."**

**Adam Matthews, Chair, Global Investor Commission on Mining 2030**

# A developing landscape

This report looks at why, and how, mining is changing in response to market demand and stakeholder influences. It analyses the impacts of those changes, and pinpoints six strategic objectives to steer institutional investors towards the Commission's vision for a more socially and environmentally responsible mining sector by 2030.

Responsible investors cannot ignore the need to expand the mining sector, and the challenges associated with it. Nor can they ignore the systemic role investors need to play to enable future demand to be met by responsible best practice operators, and for mineral rich countries to realise greater lasting in-country benefits from extraction.

The global mining industry plays a critical role in the global economy. It has a principal role in the economies of 81 countries, home to half of the world's population. It provides infrastructure, supports education and skills development, provides employment and other benefits, and contributes substantially to government treasuries. From technology to transport, chemicals to construction, the supply chains of most our products start at a mine site somewhere in the world. In fact, the industry may, ultimately, underpin as much as 45% of the global economy when both its direct contribution and its contribution to other industries are considered.

The mining industry also has a massive physical, social and environmental impact. It produced a remarkable 17.9 billion metric tonnes of minerals and metals in 2021, equivalent to 1,000 Great Pyramids of Giza.

Achieving the goals of the Paris Agreement on Climate Change requires substantial additional volumes of 'transition minerals' such as lithium, cobalt, rare earth elements (REEs) and vanadium, alongside larger volumes of traditionally mined minerals and metals including copper and iron ore. One International Energy Agency (IEA) estimate for a net zero scenario predicts that the annual demand for transition minerals for renewable energy production will triple, rising from around 10 million metric tonnes currently, to over 30 million tonnes by 2050. Meeting demand for batteries alone will require over 300 new mines, according to Benchmark Minerals. While circularity principles can reduce primary demand, the reality is that a significant expansion of mining to fulfil demand to deliver this transition will still be required.

The expected expansion of the mining sector carries important geographic, economic, social and environmental implications. If the industry fails to meet the legitimate social, economic and development needs of societies or if it fails to operate in a socially and environmentally responsible manner, it is likely to find its social licence to operate undermined and its ability to operate compromised. This, in turn, will hinder the sector's ability to deliver the minerals and metals needed for the technologies and infrastructure required for the low carbon transition.

There is a complex relationship between mining's ability to manage its environmental and social impacts, to deliver equitable and sustainable benefits, to meet future demand, and to enable net zero to be achieved. It is often not clear how these different goals and needs, which are often seen as conflicting with each other, are to be reconciled for the benefit of all stakeholders.

The Global Investor Commission on Mining 2030 (the Commission) was established to understand these goals and needs, and to build consensus on the role of finance in shaping a more socially and environmentally responsible mining sector by 2030.

## The changing landscape of mining

The positive contributions and negative impacts of the mining sector are well understood. The need to transition to a low carbon economy, and the speed at which this needs to occur if we are to avert dangerous climate change, changes the landscape of mining in two profound ways.

First, we are likely to see a shift in the geographies and commodities being mined globally. The mining industry is currently very concentrated. Just four countries - China, the US, Australia and Russia - dominate over half of total production by volume. The transition to a low carbon economy is likely to redraw the global mining map: the production of thermal coal is expected to decline sharply, and new countries will become critical actors as the production of transition minerals ramps up. For example, Chile, Brazil, Argentina, and Zimbabwe are already key lithium producers. The DRC is the main producer of cobalt with Papua New Guinea, Indonesia, Turkey, the Philippines and Cuba also amongst the top ten producers globally.

Second, the industry will be subject to even more scrutiny of its social and environmental impacts, and its contribution to local and national economic development. This is being heightened by the changing geographic footprint of the industry. Many of the transition minerals are in or adjacent to Indigenous People's lands, in water stressed areas, sensitive ecosystems areas, or in states with fragile governance and high levels of corruption.

To take just one example, mining is increasingly impacting areas of biodiversity importance. According to an S&P Global analysis and the United Nations Environment Programme (2022), of the 1,276 mining sites identified as overlapping with designated Key Biodiversity Areas, 29% are for extracting transition minerals, and most (67%) are in the exploration stage. Another aspect of concern from a biodiversity perspective is the potential for seabed mining to irreversibly alter or destroy marine ecosystems. While the potential scale of the impacts have yet to be fully understood, the International Seabed Authority has already issued over 30 contracts to companies explore deep-sea deposits, representing a total area of around 1.5 million km[2].

The focus on the social, environmental and economic impacts of mining reflects both concerns about the negative impacts but also enthusiasm that the industry can provide many positive benefits. It also reflects the potential for governments, investors and other stakeholders to positively engage with and shape the industry and to shape the context within which it operates. Of course, the landscape is complex, the industry has long been criticised for many aspects of its performance, and – as the Table below illustrates – the physical nature of the mining industry means that many of its impacts (whether positive or negative) are inevitably large and long-term.

## Major Social, Environmental and Economic Impacts Associated with the Mining Industry

### Climate change

Critical minerals have a vital role to play in enabling the transition to a low carbon economy. However, the industry has a significant carbon footprint. Mining's direct (Scope 1 and 2) greenhouse gas (GHG) emissions are estimated to account for 4-7% of global GHG emissions, and as much as 28% if indirect (Scope 3 - which include coal-fired power generation) emissions are considered.

### Economic contribution

Mining plays an indispensable role in the global economy. At the national level, mineral extraction plays a principal role in the economies of 81 countries, home to half of the world's population and to almost 70% of those living in extreme poverty. Mining accounts for over 50% of exports and between 10-20% of GDP in some nations, particularly in low- and middle-income economies where mining can be a major driver of growth and development, particularly those with strong or improving governance.

### Employment and wages

Few industries create and sustain as many jobs as the mining industry, both directly as part of the workforce and indirectly through procurement. In the US alone, the mining industry provides 1.2 million jobs. These job provide significant financial benefits to employees and to their communities. For example, in 2020, World Gold Council (WGC) member companies directly paid US$8.7bn in employee wages in 38 host countries, with 95% of the workforce comprised of local employees. Every job within a WGC member mining operation is estimated to support six further jobs, or up to ten jobs if induced jobs are included.

### Indigenous, land and resource rights

Large-scale mining is associated with complex human rights impacts and opportunities. Where not managed appropriately, this can give rise to disputes or disagreements over land and resource rights, forced or voluntary resettlement, and infringements on Indigenous Peoples' rights.

Indigenous rights are likely to feature heavily in the sector's future with over 50% of more than 5,000 transition mineral projects (active and in development) located on or near the lands of Indigenous and peasant peoples. These are groups whose rights to consultation and Free, Prior and Informed Consent (FPIC) are enshrined in international human rights law and most clearly expressed through the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP).

### Conflict over resources

Mining can be a source of intense competition and conflict, with a range of minerals sourced from conflict-affected and high-risk areas. Conflict can occur if the burdens and benefits of mining are unevenly distributed. For example, if at the local level, employees and local businesses are the immediate beneficiaries but the costs (e.g. reduced access to natural resources, pollution) are largely felt by those living closest to these mining operations. Such inequities – which often exacerbate existing inequalities – can be a key cause of tensions and conflict between companies and communities.

### In-migration

Mining operations can result in thousands of new people coming to an area. This can have many positive economic and social benefits. However, it can also result in local competition for jobs, housing shortages and increased stress on natural resources.

## Infrastructure
Mining operations frequently deliver vital local infrastructure such as roads, airstrips, railway, water and sanitation systems, health clinics and electricity.

## Labour rights
Labour issues vary across the global sector and the picture is mixed. Concerns have been expressed about occupational health and safety (with the ILO estimating that about 8% of fatal accidents at work occur in the mining sector), conditions and pay, discrimination, and restrictions on collective bargaining. However, many companies have actively supported trade unions, enabled collective bargaining, provided jobs with greater benefits and enhanced opportunities for minorities.

Though it provides an income for millions of people, especially in developing countries, Artisanal and Small-scale Mining (ASM) is particularly associated with child and forced labour, and with extremely hazardous working conditions.

## Land use and ecosystems
Mining operations have a large physical footprint, with the potential for significant negative impacts on ecosystems. This is exacerbated by the reality that many current and proposed mining sites are located in areas of biodiversity importance. The land use impacts of mining are not confined to direct operations; some of the benefits of mining (e.g. the development of transport infrastructure, in-migration as a result of employment opportunities) contribute to environmental degradation in a much larger area than the local footprint of a mine.

## Pollution
Many mining operations have been criticised for water, soil and air pollution. This can occur, for example, through acid rock drainage, through water pollution as a result of heavy metals leaching from waste storage facilities, from the leaking of mercury or cyanide, or from mine dust emissions.

## Waste management and tailings
Mines create vast volumes of solid waste and tailings, and the demand for transition minerals is predicted to generate an additional 13 billion tonnes of waste rock annually. The failures of tailings facilities – an average of five significant failures occur every year - have had major environmental impacts and such failures have killed at least 2,375 people since 1960.

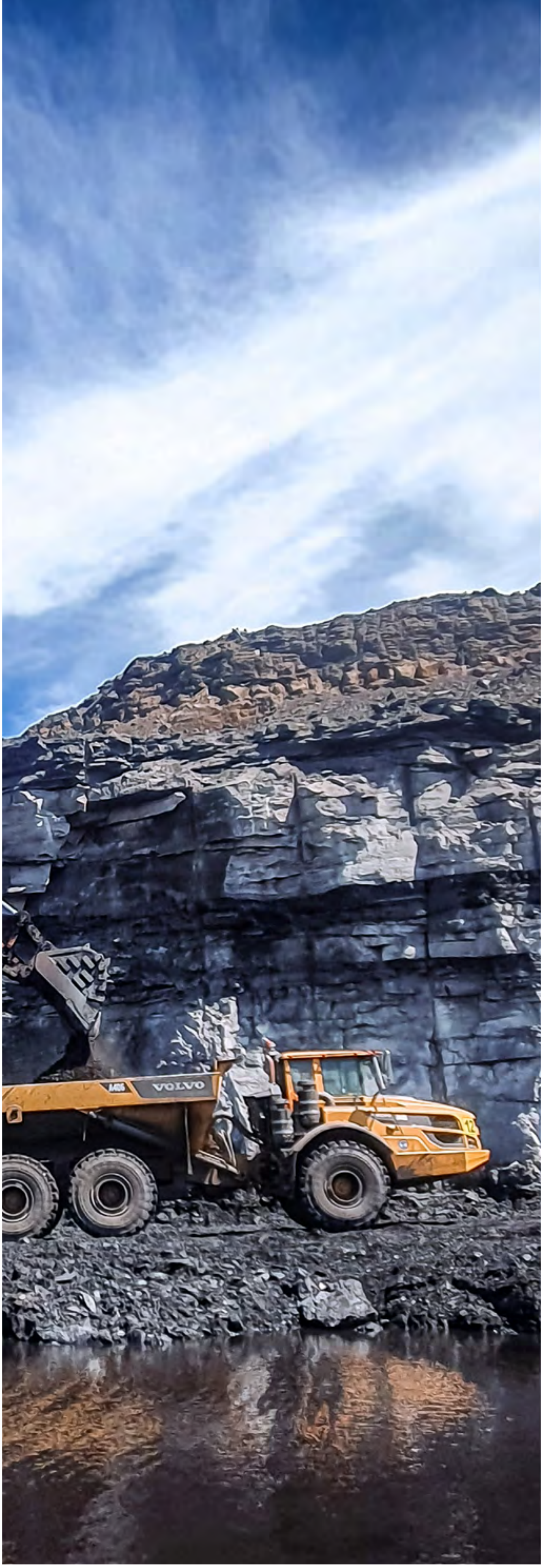
## Water use
Mining can be very water intensive and can alter local hydrology. Over 70% of mining operations for the six largest listed mining companies are in water-stressed countries.

## Investors' role in shaping the mining industry

Given the scale of the positive and negative impacts of the mining industry, and the urgency – in terms of ensuring the social licence to operate of the industry – one of the central questions for the Commission is what role can, and should, investors play to maximise the benefits and minimise the negative impacts?

Institutional investors[1] have several levers they can use to drive change in the mining value chain:

- **Capital allocation:** Investors can preferentially allocate capital to and provide incentives (e.g. lower interest rates) to those companies exhibiting or moving towards best practices. They can also help finance the growth of the circular economy and support post-mining land restoration.
- **Active stewardship with mining companies:** Investors can engage, individually or collaboratively, with investee companies to improve sector performance. Listed equity investors can and do engage with mining majors to set expectations of current operations and, where they have partnerships with junior mining companies, on exploration. Debt investors can impose social and environmental requirements as part of loan conditions, can monitor performance against these requirements and can engage with the companies to ensure they identify and effectively manage the environmental, social and economic impacts of their mining and related activities.
- **Active stewardship with downstream players in the mining value chain:** Investors can engage with value chain companies, exchanges and markets to encourage them to align on their expectations of the industry.
- **Collaborating with other finance institutions:** Investors can work with other financial institutions to encourage good practice. For example, they can engage with banks to ask them to enforce high standards of social and environmental performance when lending to mining projects, and encourage stock exchanges to add relevant criteria to listing rules.
- **Policy engagement:** Institutional investors can encourage governments, whether at specific jurisdictions (local, national) or at international level, to set policies that incentivise responsible mining and disincentivise negative impacts. Investors can also engage with governments to grow infrastructure related to the circular economy.




1. The Commission is supported by many large, diversified institutional investors. They invest in a range of asset classes including listed equities, corporate debt, government debt, private equity, property and infrastructure. The recommendations in the report are therefore tailored to this class of investors, and based on an understanding of how they can shape the mining sector (directly and/or through other investors) and where, in the context of the mining sector, this can be most impactful.

## Phases in the life of a mine


The question is not just *what* change investors can bring to bear, it's also *when*. At the operational stage, institutional investors can engage with listed major companies where they have a direct relationship. Here, investors can require companies (and other financial actors, e.g. private equity investors) to adopt and deliver against robust standards of social and environmental performance. The challenge is that, by the time the operational stage is reached, it is difficult to retrofit standards to an operational facility and there is, therefore, less potential for investors to reduce impact.

While the earlier stages of the mine lifecycle such as exploration, feasibility, design and construction offer the potential for greater reductions in impact, institutional investors will generally need to work with intermediaries to effect change in these stages. However, there are some specific points where institutional investors can be influential:

- **Exploration:** Institutional Investors can engage with the major companies to set clear social and environmental expectations of the junior companies that they partner with, and who dominate this segment of the mine lifecycle. Investors can also encourage stock exchanges – e.g. the Toronto (TSX) and Australian (ASX) exchanges where many juniors list - to set clear expectations on responsible mining.
- **Feasibility:** Institutional investors can engage with private equity, venture capitalists, the royalty and streaming companies[2] and development banks who are active in this segment, to encourage them to adopt and effectively implement robust social and environmental performance standards for the mining companies that they are financing.
- **Planning, design and construction:** Institutional investors can press the banks who lend to this segment and private equity funds to adopt robust social and environmental performance standards, to ensure these are incorporated into contractors' management plans, and to ensure that these are effectively implemented.
- **Closure:** Institutional investors can collaborate on post-closure opportunities with affected stakeholders.

To drive better practice across the industry, institutional investors can also work collectively to:

- **Develop consolidated investor expectations of the mining industry,** for example through harmonisation of investor expectations in terms of standards, indicators and methodologies that provide a common understanding of good practice and drive company progress.
- **Facilitate long-term, patient capital across the mining lifecycle**, that enables the adoption of high standards of social and environmental performance.
- **Reflect investor expectations of high social and environmental performance across the entire value chain,** including promoting an integrated approach to circularity.
- **Encourage financial institutions (e.g. asset managers, banks, lenders, export credit agencies) and intermediaries (e.g. stock exchanges) to adopt high ESG standards.**
- **Recognise high standards of performance and positive contributions within ESG frameworks and ratings.**
- **Explore development of an investment vehicle**, to incentivise industry good practice and to channel capital to activities that reduce mining-related harms and promote positive impacts.

2. Royalty and streaming companies fund mines in exchange for money or precious metals.

## Public Policy Engagement

While investors have considerable ability to shape the mining sector, they do not exist in isolation. The Commission recognises the need for support from governments and civil society to achieve its vision of a socially and environmentally responsible sector by 2030.

Effective state governance over mining operations is critical to both reduce negative impacts and to enable greater social benefits. This includes the adoption and effective implementation of high social and environmental performance standards for the mining industry. Most countries have regulatory frameworks covering requirements for matters that include: legal (e.g. licensing), technical (e.g. geological mapping and mineral exploration), fiscal (e.g. royalties and taxes), and social and environmental (e.g. engagement with affected communities, management of pollution, ensuring traceability and high standards across the value chain) items.

Where these governance frameworks function well, mining is more likely to be a net benefit to a country and its people. Though even with strong regulations, the quality, scope and enforcement of these frameworks varies between jurisdictions and can be found wanting. When governments fail to effectively implement these requirements, mining operations can lead to environmental degradation and negative social impacts, and can cause or exacerbate conflict. This is likely to be even more important in the years ahead, as countries with reserves of transition minerals are often also those with middle to high measures of fragility and corruption. An estimated 70% of global cobalt and 73% of graphite reserves – vital for the batteries and fuel cells in our renewables and EVs – are located in fragile or very fragile jurisdictions.

Policymakers can build a wider enabling environment that affects national and global financial flows. All governments – of both mining and consumer states - have a key role in creating the right incentives and policy environment for a more responsible mining industry across the entire value chain. Alongside policy leadership, collective action by institutional investors, civil society organisations, mining companies, local rights holders and affected stakeholders, and academia is needed. Investors can engage and convene these different stakeholders to align on standards, encourage good practice through the industry and find solutions collectively. Investors can, along with other stakeholders, differentiate between good and bad performing companies so that investment and opportunities can be channelled towards companies which are operating in a responsible manner and that show clear evidence of improvement in their social and environmental performance.

**When it comes to climate change, the stakes are high. So, responsible mining is critical to supply the clean technologies necessary for a low carbon economy. We need to hardwire effective sustainability standards into management systems, and the institutional investment community is ideally placed to do so."**

**Barend Peterson, Vice- Chair, Global Investor Commission on Mining 2030**

## Objective setting

Based on our analysis, the Commission is proposing a set of strategic objectives to take forward into a second phase of planning. They are focused on those common, underlying issues that, if addressed, would transform the industry's social and environmental performance, and on those areas where investor interventions can deliver substantial positive impact.

The objectives (Figure 1) focus on improving social and environmental performance of the mining industry through:

1. Developing investor expectations aligned with global and industry standards
2. Wider application of circularity principles and alignment of value chain industries with investor expectations;
3. Building regulation, incentives and institutional frameworks at global, regional and national levels that reinforce investor expectations;
4. Generating sustained benefits at local and national levels through improved equity and transparency in decision-making and benefit distribution;
5. Reducing mining as a driver of conflict through improved identification and management of risks linked to mining-related impacts and revenues;
6. Driving safe and responsible mine closure and addressing historic legacies of mining.

**These six objectives will form the basis for the next phase of the Commission's work which will focus on developing workplans for each of these strategic areas. The Commission will deliver these by 2030.**


All data sources and references used in this Executive Summary can be found in the main report at mining2030.org

*Figure 1. Strategic Approach of the Global Investor Commission on Mining 2030*

### About The Global Investor Commission on Mining2030

The Commission is a collaborative investor-led initiative, seeking to develop a consensus about the role finance has in realising a vision of a socially and environmentally responsible mining sector overall by 2030. It aims to work collectively with the finance sector to develop sector-wide standards and encourage best practices. https://mining2030.org

### The process of objective setting

The first phase of work involved researching the mining landscape as a basis for the development of strategic objectives and priority actions. This included researching current and projected production, challenges and impacts, and where investors can have most impact. The research for this report was conducted through a desk-based review and on-going consultation with Commission members. Based on this research, and in collaboration with Commission members and an Investor Support group, the initiative has identified and developed six strategic objectives. The next phase will focus on developing workplans for each of these strategic areas, which the Commission will then deliver by 2030.

# References for Introduction


1. Reichl C, Schatz M. (2023). World Mining Data 2023. Federal Ministry of Finance Republic of Austria Available at: https://www.world-mining-data.info/?World_Mining_Data___Mineral_Raw_Materials.

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# 1. Overview of the Mining Landscape

Mineral production is rising rapidly driven largely by coal (43% of the global total in 2021) and iron ore (17.3% in 2021). This compares with an increase of around 3.2% for transition minerals, including bauxite but excluding iron ore. The future will likely look very different as the expected push for decarbonisation accelerates demand for transition minerals. While predictions vary in relation to scale and speed, there is broad consensus that demand for most major metals (especially aluminium, copper, nickel, and zinc) is likely to increase throughout this century. If these predictions hold true, more diverse sources of production will be required across both existing and perhaps new geographies. This is likely to spur a continuous expansion in mining activity.

Any increase in mining will carry substantial economic, social, and environmental implications. Governance - of countries and companies - will prove to be a critical factor in determining the balance between the positive and negative impacts of mining. Robust governance generally supports wealth creation and sustainable development alongside the growth of mining. However several states where transition minerals will be sourced from suffer from high rates of political instability and state fragility heightening risks of violence, conflict, and human rights abuses. Past commodity booms have corresponded with increased corruption, so a similar trend may accompany a surge in demand for transition minerals.

For investors, companies, and governments (seeking security of supply), these contextual risks will be accompanied by logistical, resourcing, and diversification challenges. Average lead times (from discovery to production) have stretched to nearly 18 years (up from 13 in 2009). This increases costs and compounds the expected shortfall in the capital investment required to meet predicted demand. The supply of many key minerals remains too concentrated. In total 81% of lithium, 50% of bauxite, and 44% of iron are sourced from just ten mines, while Chinese companies are responsible for most of the production of 21 transition minerals.

Although these challenges are not wholly new, they are becoming more pressing. In part this is due to the urgency of the transition to a low-carbon economy, in part it's because of the deteriorating geo-political environment which is likely to favour transnational division and competition over cooperation and collaboration. Amidst these myriad challenges, a responsible mining sector is more important than ever. Those living and working, literally and metaphorically, at the coalface should not be forgotten in the rush towards a greener economy.

# 1.1. Current Global Production Volumes

**Key Takeaways**

- Coal (thermal and metallurgical) remains the most heavily mined mineral, by a distance.
- Transition minerals comprise only a tiny fraction of total mining production.

## 1.1.2. Production Volumes

In 2021, global mining production stood at 17.9 billion metric tonnes,[1] the equivalent of 1,000 Great Pyramids of Giza. This is an increase of 58% from the previous year and double the total in 1985.[1] Coal production (thermal and metallurgical) accounted for almost half (43%) while iron ore was the next most mined mineral by mass. Phosphate rock also saw notable increases, with production tripling in 2022[1] compared with 2021.[2] Transition minerals (including bauxite but excluding iron ore and uranium) collectively accounted for around 3.2% of total mined goods in 2022.[i]

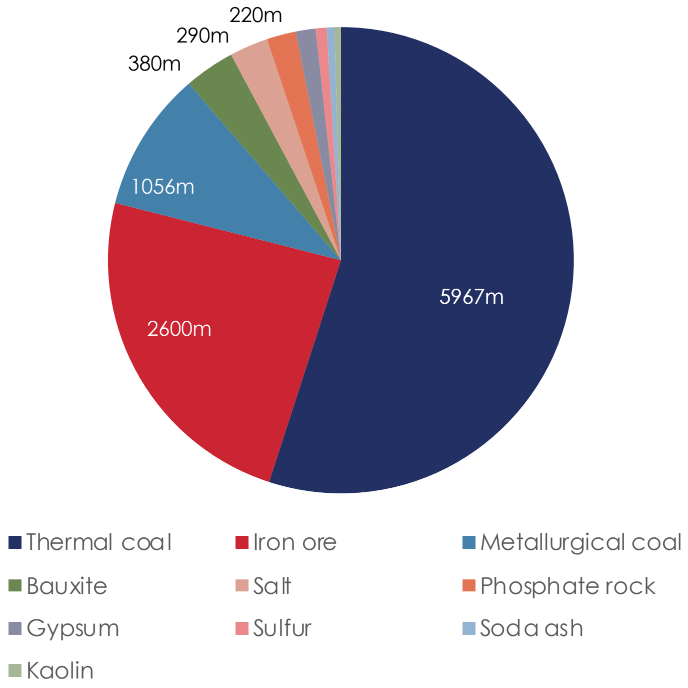



*Figure 1.1. The top 10 most heavily mined minerals (million metric tonnes)[ii]*

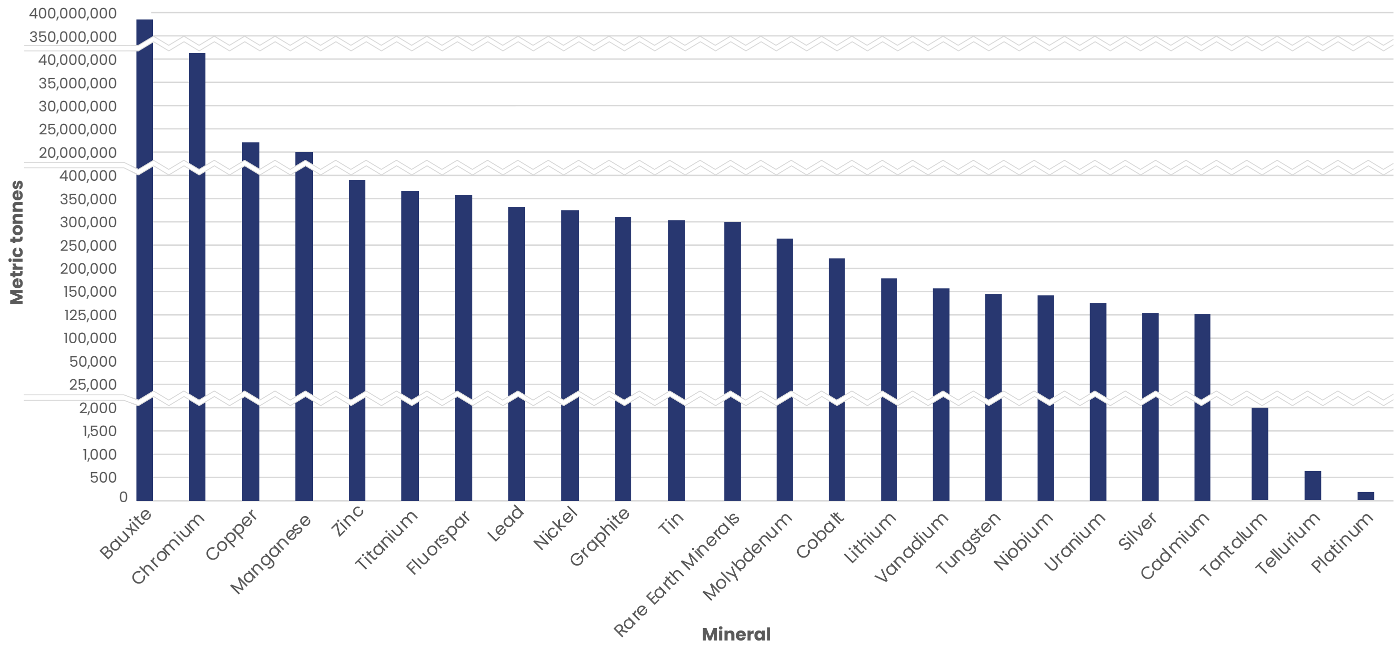



*Figure 1.2. Global production volume of transition minerals[iii]*

i Calculated using data for all transition minerals for which data were available (2022 production) in US Geological Survey (2022). Mineral Commodity Summaries 2022. US Department of the Interior. usgs.gov/centers/national-minerals-information-center/mineral-commodity-summaries combined with coal data (2021 production) from Reichl, C., & Schatz, M. (2023). World Mining Data 2023. Federal Ministry of Finance, Republic of Austria. https://world-mining-data.info/wmd/downloads/PDF/WMD2023.pdf.

ii Data Sources: US Geological Survey (2022). Mineral Commodity Summaries 2022. US Department of the Interior combined with coal data (2021 production) from Reichl, C., & Schatz, M. (2023). World Mining Data 2023. Federal Ministry of Finance, Republic of Austria. https://world-mining-data.info/wmd/downloads/PDF/WMD2023.pdf.

iii Data Source: US Geological Survey (2022). Mineral Commodity Summaries 2022. US Department of the Interior.

## 1.2. Geography of Current Production

**Key Takeaways**

- Asia accounts for over 60% of all minerals mined globally.
- Production is still dominated by established producers (China, USA, Australia, Canada).
- Greater diversity is evident in the mining of transition minerals...
- ...but processing of transition minerals is heavily concentrated in China.

### 1.2.1. All Minerals

By continent, Asia is by far the largest mineral producing continent, at approximately 10.8 billion metric tonnes in 2021, followed by North America at 2.7 billion metric tonnes (Figure 1.3).

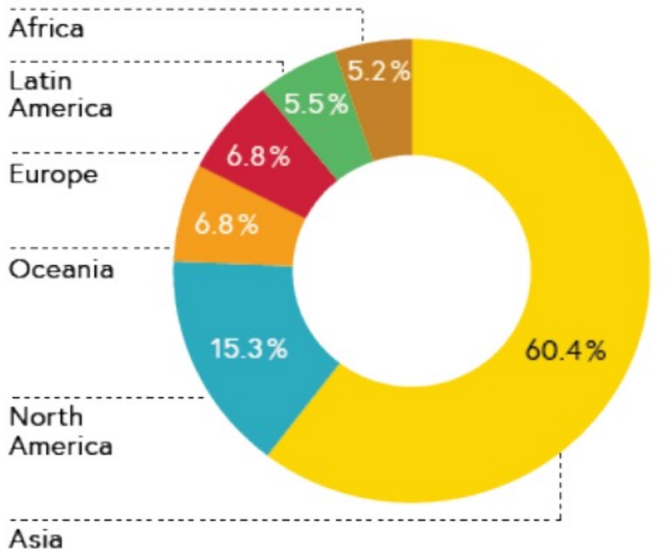



*Figure 1.3. Total Mineral Production Volume by Continent, 2021. Source: Reichl & Schatz (2023).[1]*

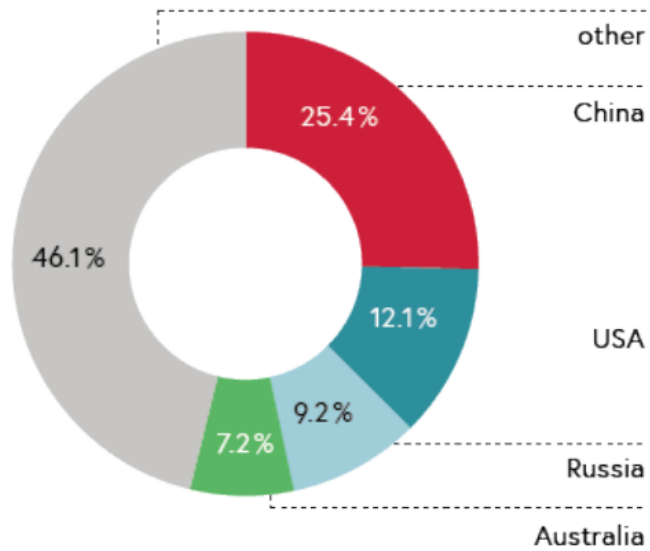



*Figure 1.4. Total Production by Country, 2021. Source: Reichl & Schatz (2023).[1]*

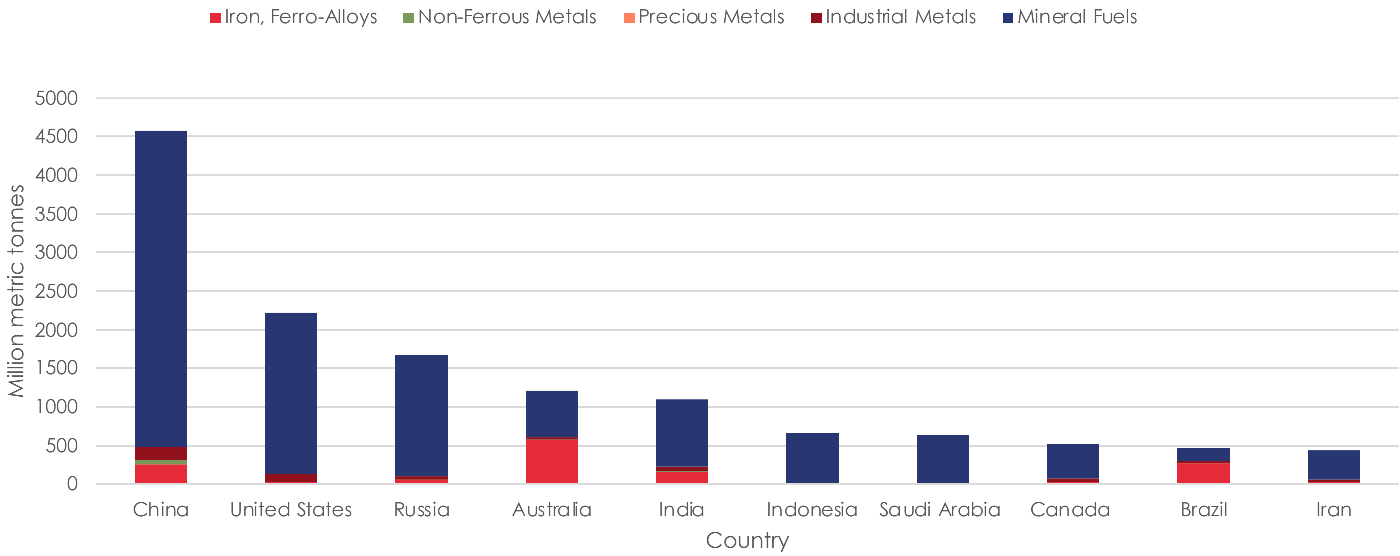



*Figure 1.5. Total Mineral Production Volumes of the Top 10 Mineral Producing Countries, with Mineral Categories Shown.*[iv]

By country, China is comfortably the largest mineral producer (Figure 1.4). It leads the production of 21 minerals globally although its dominance in terms of volume is heavily weighted towards coal and iron ore. USA, Russia and Australia and India are the next biggest producers. With the exception of Australia and Brazil, mineral fuels (coal) dominate production amongst the highest producers. Indonesia, Saudi Arabia, Canada and Iran are also significant producers of coal. In Brazil and Australia, iron ore makes up around half of production.

### 1.2.2. Transition Minerals

The supply of transition minerals is more diverse than production as a whole, with developing and transition countries (Figure 1.6), particularly in South America, Southeast Asia, and Africa, becoming more prominent alongside China and Australia. For example, Chile, Argentina and Bolivia are important producers of lithium (Figure 1.7) and Peru is a key producer of zinc (Figure 1.8). Indonesia and the Philippines have emerged as important actors in nickel production (Figure 1.9), and the Democratic Republic of Congo (DRC) and Chile are the largest producers of cobalt (Figure 1.10) and Copper respectively (Figure 1.11).

iv Data source: US Geological Survey (2022). Mineral Commodity Summaries 2022. US Department of the Interior.

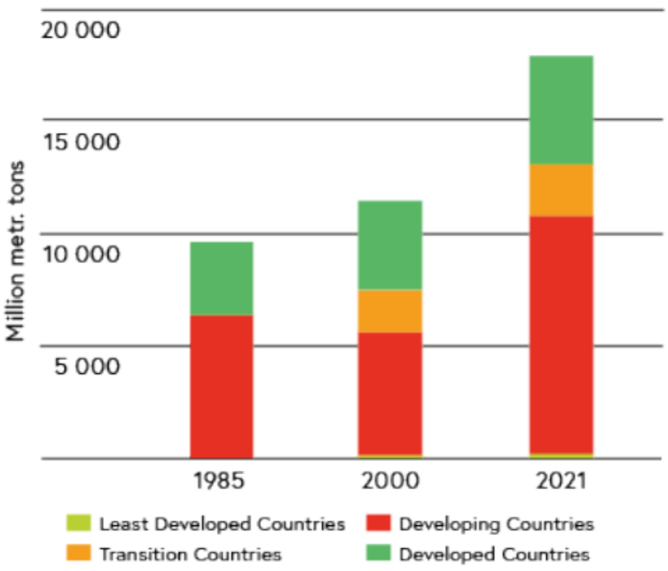



Figure 1.6. Development Status of Producer Countries. Source: Reichl & Schatz (2023).[1]

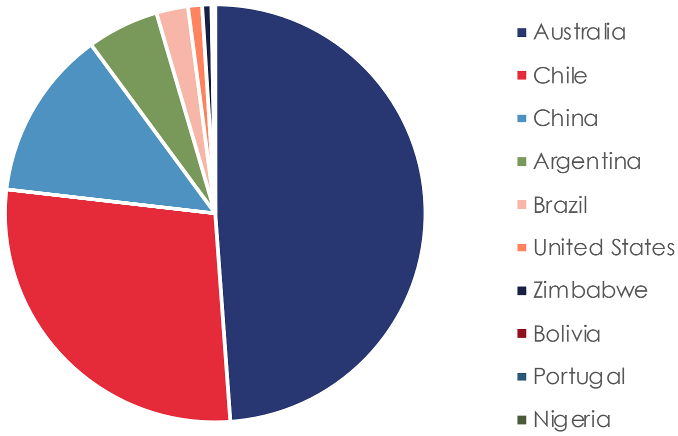



Figure 1.7. Top 10 Lithium Producers in 2021[v]

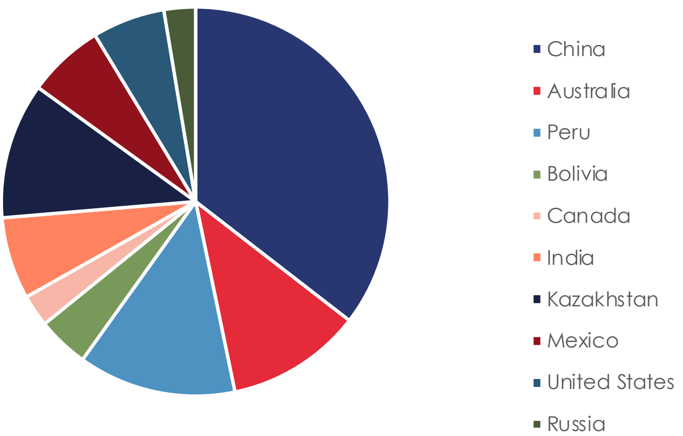



Figure 1.8. Top 10 Zinc producers in 2021[v]

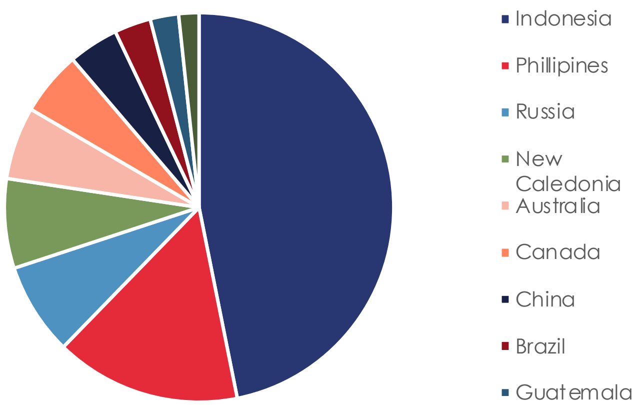



Figure 1.9. Top 10 Nickel producers in 2021[v]

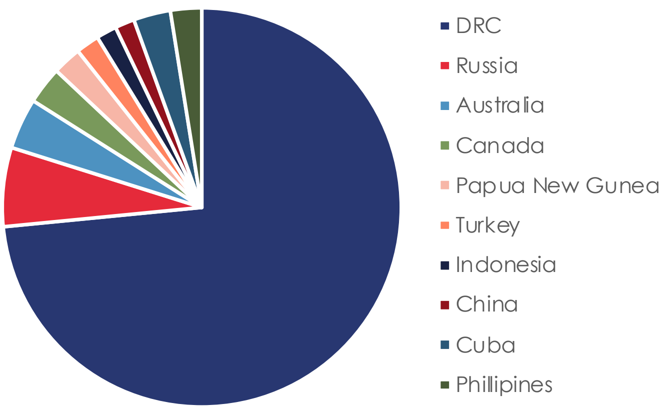



Figure 1.10. Top 10 Cobalt producers in 2021[v]

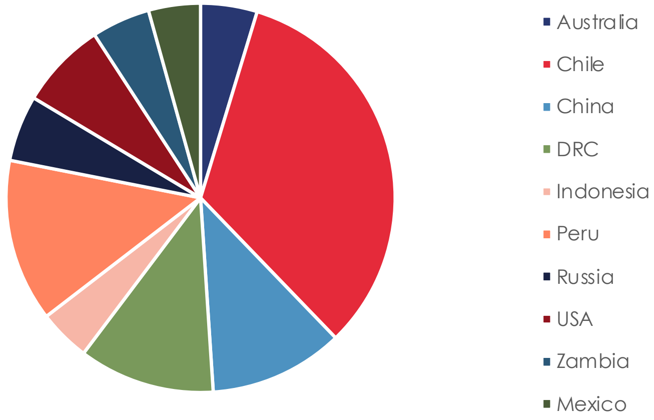



Figure 1.11. Top 10 Copper producers in 2021[v]

v Data source for Figures 1.7 to 1.11: Reichl, C., & Schatz, M. (2023). World Mining Data 2023. Federal Ministry of Finance, Republic of Austria. https://world-mining-data.info/wmd/downloads/PDF/WMD2023.pdf

### 1.2.3. Mineral Processing

For coal, processing and refining mirrors extraction and is heavily concentrated in China, India, the US, Indonesia, Australia and Russia.[4]

China also leads the world in iron and steel processing, equivalent to 43% of global steel and 51% of iron production capacity.[3] This is followed (for both iron and steel production) by India, Japan, Russia, Iran, South Korea and Germany. The United States has the second highest steel production capacity (after China). Australia has the largest capacity for bauxite refining.[4] Brazil, Australia, China, Germany, and Ukraine, also make alumina exports and are important geographies in bauxite refining.[5]

China dominates the processing of transition minerals, refining around 35% of nickel, 40% of copper, 50-70% of lithium and cobalt, and 90% of Rare Earth Elements (REEs) globally in 2019.[6] Other developed countries, such as South Korea, Japan, Germany, and Canada are significant players (Figure 1.12).[7,8] In addition, many nations involved in upstream operations are active in mineral processing. For example, Indonesia accounts for the majority of global nickel processing and Chile comes second only to China in the processing of copper and lithium.[6]

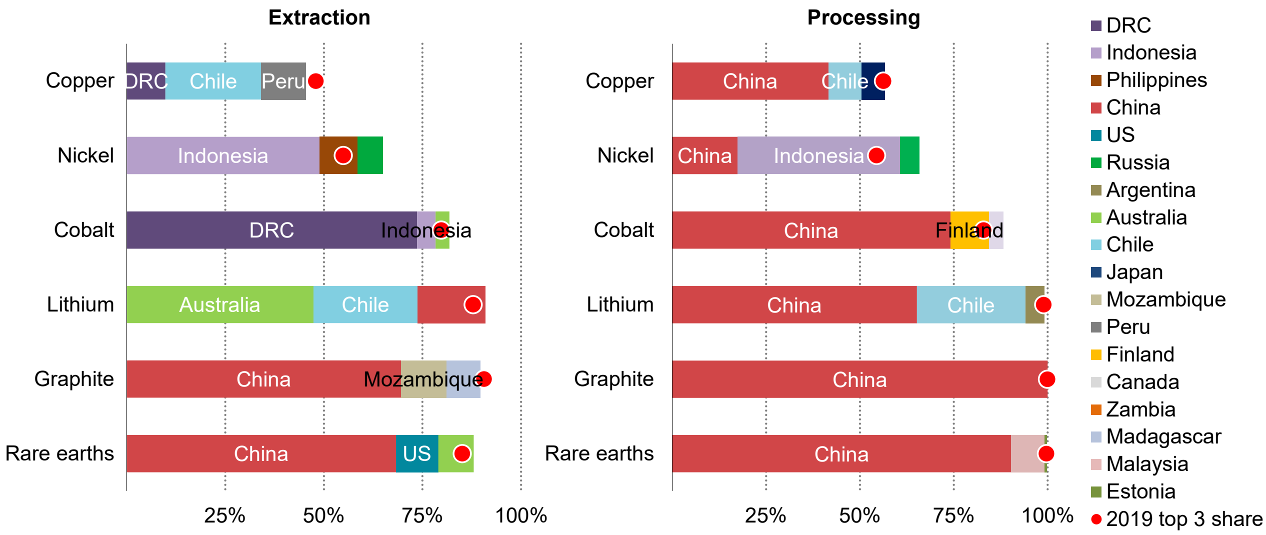



*Figure 1.12. Share of Top Three Producing Countries in Total Production for selected Minerals, 2019. Source: IEA (2023).[9]*

## 1.2.4. Mineral Imports

China imported mineral products worth $557 billion in 2021, up 42% from the previous year,[10] making it the world leader (Figure 1.13). Whilst coal accounted for a large proportion of this, the year-on-year increase can be partially attributed to growth in the country's manufacturing of EVs, Photovoltaic (PV) technologies, and wind turbines.[6] The US came a distant second at US$216 billion, again largely consisting of coal. Whilst Asian countries such as Japan, India and South Korea, follow behind with a collective value of US$489 billion.[10] It is notable that European countries are increasingly significant importers of transition minerals for clean energy technology manufacturing and installation.[6]

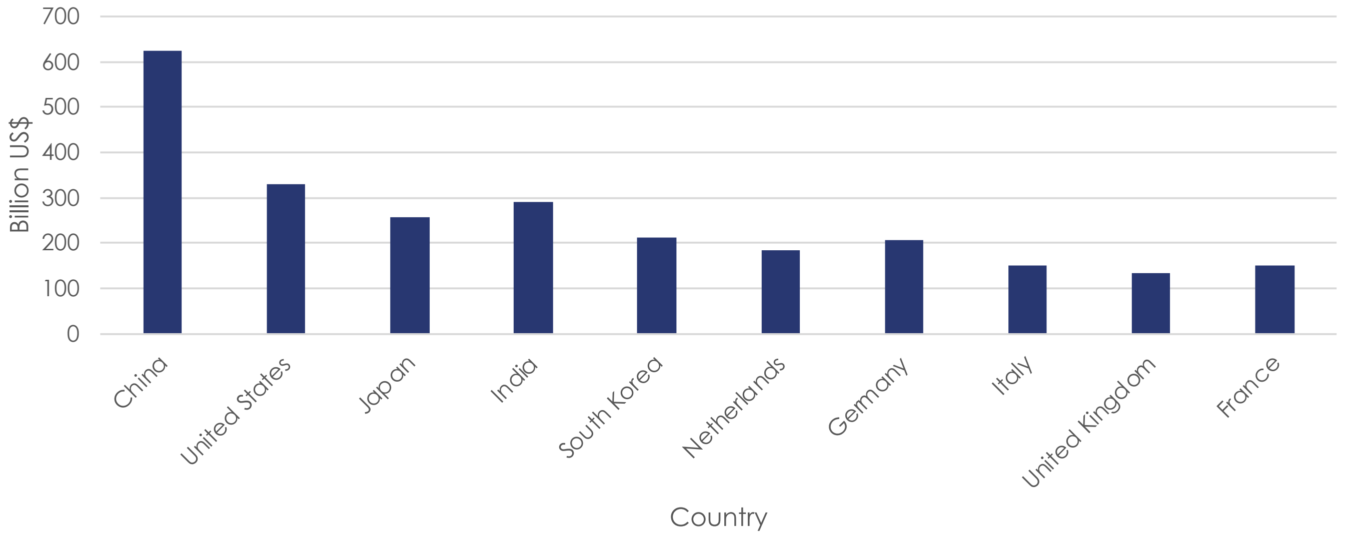



*Figure 1.13. Value of Imported Mineral Products by Top 10 Importing Countries.*[vi]

vi Data Source: US Geological Survey (2022). Mineral Commodity Summaries 2022. US Department of the Interior

# 1.3. Projected Mineral Production

**Key Takeaways**

- Coal and iron ore will remain the most heavily mined minerals for the foreseeable future but there is uncertainty as to when, and to what extent, production will fall.
- Production of transition minerals will grow sharply in the coming years but how far and fast is subject to many variables.

## 1.3.1. Mineral Demand Projections

### Coal

Global phasing out of coal by mid-century is considered vital to achieving the Paris Agreement's goal of limiting warming to well-below 2 °C above pre-industrial levels.[11] At this time, there is no consensus on projections for future coal production. Variables include the speed and extent of the scaling of renewable energy (with a consequent phasing out of coal), and the efficacy of new technologies such as Carbon Capture and Storage. With so many uncertainties, scenarios replace predictions with each making different assumptions about what the next few years will or should bring.

For example, under a Stated Policies (STEPS) scenario, coal production would decline to 73% of 2021 levels (of 7,947Mt) by 2025 and, under a Sustainable Development (SDS) scenario, the reduction would be even steeper, to 54% of 2021 production by 2025.[12] These are followed by declines at less substantial rates between 2025 and 2030 to 58% (STEPS) and 40% (SDS) of 2021 production volumes.

Over the longer-term, under an Announced Pledges (APS) and Net Zero Emissions (NZE) scenario, coal demand would decrease by 2050 to 20% and 7% of 2021 production respectively (Table 1.1). All these scenarios assume a steeper reduction in thermal vs metallurgical coal. Thermal coal is used primarily for heating and electricity (which is increasingly being replaced by renewables) while metallurgical coal is used mainly for steelmaking and has fewer available alternatives.

In contrast, most baseline scenarios predict a much higher coal dependency than over the past 60 years.[13] There are also a range of 'coal persistence' scenarios compatible with global targets, which are generally pessimistic about the scaling of renewable energy technologies but optimistic about the rapid scaling of Carbon Capture and Storage Technology (CCS).[13]

The current state of play in the coal industry offers perhaps the best gauge of future coal production, at least in the short-medium term. There were 2,384 proposals for new coal mines in 2023.[14] In 2021, the Global Coal Mine Tracker reported that 2,277 million tonnes per annum (Mtpa) of new coal mining capacity was under development, representing 28% of production (7,947Mt) in the same year.[15]

Some of the projections envisage strong declines in coal demand across most of the world, only partially offset by an increase in certain regions, for example in India and Indonesia (Table 1.2). With that said, however, China, Australia, India, and Russia make up over three-quarters of new mine developments,[15] suggesting that some of the more aggressive 'coal phase-out' scenarios look increasingly fanciful. Due to a time lag in fossil fuel reduction policies, commitments and visible impact, any potential significant decline in coal supply is more likely to occur between 2030 and 2050.

| Scenario | 2021 Production[2] | 2025 Projected Demand (metric tonnes of carbon equivalent)[16] | 2030 Projected Demand (metric tonnes of carbon equivalent)[16] | 2050 Projected Demand (metric tonnes of carbon equivalent)[16] |
|---|---|---|---|---|
| Stated Policies Scenario (STEPS)[vii] | 7025Mt | 5,800Mt, 73% of 2021 production. | 4,600Mt, 58% of 2021 production. | 3,820Mt, 48% of 2021 production. |
| Sustainable Development Scenario (SDS)[viii] | 7025Mt | 4,300Mt, 54% of 2021 production. | 3,200Mt, 40% of 2021 production. | Not Available |
| Announced Pledges Scenario (APS)[ix] | 7025Mt | Not Available | Not Available | 1,610Mt, 20% of 2021 production. |
| Net Zero Emissions by 2050 Scenario[x] | 7025Mt | Not Available | Not Available | 530Mt, 7% of 2021 production. |

*Table 1.1. Projected Mineral Demand for Coal by Scenario. Data Source: IEA (2023).[16]*

| Region | Demand under STEPS Scenario to 2030 (from 2021) | APS Scenario to 2030 (from 2021) | Demand under STEPS Scenario to 2050 (from 2030) | APS Scenario to 2050 (from 2030) |
|---|---|---|---|---|
| **Advanced Economies** | Reduce by 60%. | Reduce by 80% less coal, due to increased use of renewables and natural gas. | Reduce by 45%. | Not available |
| **China** | Peak in the late 2020s and begin to reduce as the construction industry demands 80% less coal | Peak in the mid-2020s, and decline more significantly by 2030, due to natural gas, electrification, and greater energy efficiency. | Coal power plant production would fall by 21%, and utilisation by 10%, decreasing overall coal demand by 40%. | Demand would drastically fall, by over 1000Mt from 2030, as coal power plant production would fall by 25% and utilisation by 20%. |
| **India** | Increase by 25% | Increase by 15% between 2021-2030, due to a more substantial use of natural gas, growing electrification, and energy efficiency. | Decline due to the greater application of renewables but would remain higher than 2021 demand. | Fall by 65% between 2030 and 2050. |
| **Southeast Asia** | Increase by 30% | Coal demand would increase by 10%. | Not Available | Not Available |
| **Africa** | Remain stable | Renewables would reduce coal demand by 20%. | Not available | Not available |
| **Russia** | Reduce by 30%, primarily due to the increased use of renewables and natural gas. | Coal demand would shrink by 30%, primarily due to the increased use of renewables and natural gas. | Not available | Not available |

*Table 1.2. Projected Mineral Demand for Coal by Low Carbon Transition Scenario and Region. Data Source: IEA (2022).[17]*

vii A scenario modelled by the IEA which accounts for both national government's policies which have been announced, and those which are under development. Therefore, the scenario is more conservative than the Announced Pledges Scenario, as it recognises that not all government goals will be met.

viii A scenario modelled by the IEA in which the energy sector meets the UN's energy-related goals, the Paris Agreement's climate goal (SDG 13), provides universal access to modern energy by 2030 (SDG 7), and significantly reduces energy-related air pollution and the subsequent adverse implications for public health (SDG 3.9)

ix A scenario generated by the IEA's Global Energy and Climate Model in which assumes that all climate commitments made by governments and industries around the world by the end of August 2023, including Nationally Determined Contributions (NDCs) and longer-term net zero targets, as well as targets for access to electricity and clean cooking, will be met in full and on time.

x A scenario modelled by the IEA in which the global energy industry achieves net zero carbon dioxide emissions by 2050.

## Iron Ore

Predictions for iron ore are a little clearer than for coal, albeit for different reasons. Most envisage some reduction by 2030 from 2022 levels (Figure 1.14). This is largely as a result of falling Chinese steel demand as the country's urbanisation slows, but also the longer lifecycles of steel products and increased scrap recycling.[18] However, much depends on India with the World Steel Association predicting that the country's economic growth will drive overall increases in demand, at least in the immediate future.[19]

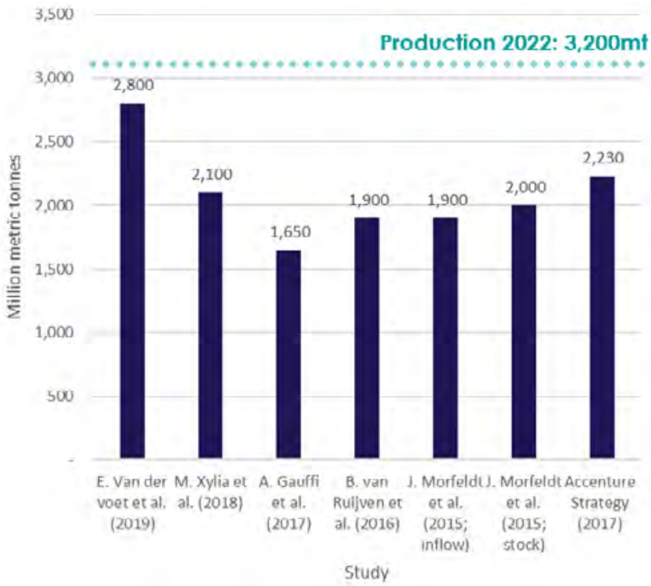



*Figure 1.14. Various Projections for Iron Ore Demand in 2030.[xi]*

Technological innovation provides another variable. In the case of iron ore, recycling holds real potential as does the means of processing. An NZE scenario assumes the global steelmaking industry will employ a larger volume of direct reduced iron (DRI), increasing demand for DRI from 36% (2023) to 54% in 2050.[22,23] DRI is produced through hydrogen-based processes, as opposed to coal-powered blast furnaces, but requires a higher grade of ore.[24] While the overall supply of iron ore is likely to meet demand, mostly due to sufficient reserves, technological development, and steel recycling, the high-grade iron ore market is expected to experience a supply shortage in 2030, particularly of DRI pellets.[24] DRI is currently more costly to produce, but development of new DRI projects is underway, and India, which is expected to provide almost one-fifth of the steel produced globally by 2050 (compared to around 5% today) is experienced in DRI production[25] as well as a leader in scrap metal recycling (see Country Case Study 1).

xi Data points as presented in Watari et al (2021) Major metals demand, supply, and environmental impacts to 2100: A critical review, Resources, Conservation and Recycling, Volume 164, https://doi.org/10.1016/j.resconrec.2020.105107; and in Accenture Strategy (2017) 'Steel Demand Beyond 2030: Forecast Scenarios'. https://web-archive.oecd.org/2017-10-04/450834-Item_4b_Accenture_Timothy_van_Audenaerde.pdf

### Country Case Study 1: Coal, Iron Ore and Scrap Metal Recycling in India

India is a significant producer of a range of minerals but is focused particularly on coal and iron ore with growth in production in 2023 of 16% and 17%, respectively.[26] The country is the second largest producer and consumer of coal after China.[27] Thermal coal production in India has grown rapidly, increasing by >22% since 2019.[26]

India's National Mineral Policy (2019) aims to increase the production of major minerals by 200% in seven years. This includes an increase in steel production capacity through scrap by 60%, to reduce crude steel's carbon footprint by 50% by 2030.[28] India is also making efforts to promote circularity with a focus on scrap metals, including reducing import duty on copper scrap from 5% to 2.5% in 2021 to boost its role in recycling.[26] Notably however, at COP26 in Glasgow, India played a key role in diluting a pledge to 'phase out' coal, instead committing to 'phase down' coal.[29]

## Transition Minerals (excluding Iron Ore)

Scenarios on coal and iron ore demand appear almost prophetic compared with those for transition minerals. Projections vary considerably depending on the methodology, assumptions and scenarios used.[20] In addition, existing scenarios tend to consider only clean energy production (wind, solar etc) and do not take into account potential demand from emerging technologies in other industries (Information Technology etc). This makes accurate projections an even more fraught process. The IEA does provide estimates for mineral demand from clean energy technologies up to 2040 based on STEPS and SDS (Figure 1.15) scenarios. Even here, however, the two methodologies provide very different forecasts.

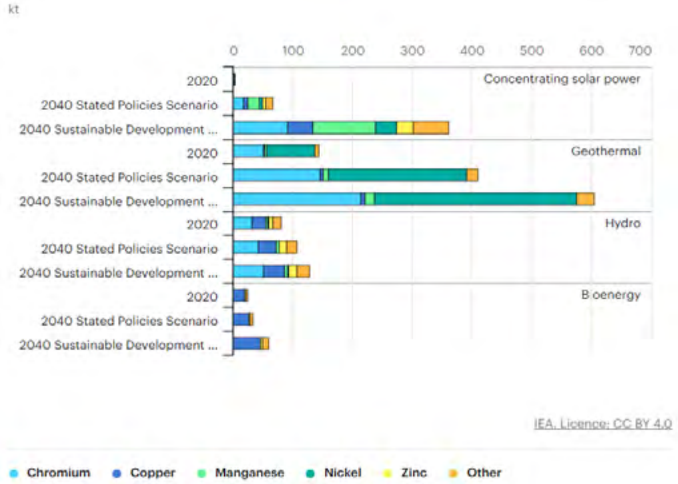



Figure 1.15. Annual Mineral Demand from Renewable Technologies by Scenario, 2020-2040. Source: IEA (2021).[6]

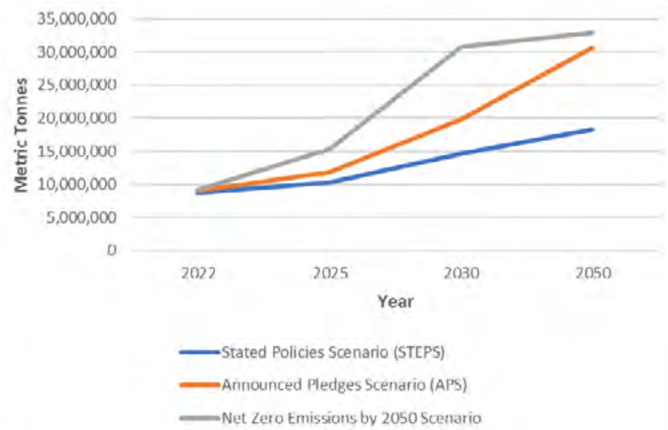



Figure 1.16. Total Projected Future Transition Mineral Demand from the Renewable Energy Sector Under the STEPS, APS and NZE Scenarios. Source: IEA (2024).[31]

Notwithstanding the variations, it is reasonable to assume that demand for all transition minerals will increase significantly by 2030 (and beyond) from current production levels. Anything else would signal a virtual abandonment, or at least postponement, of the transition to a low-carbon economy. The energy transition alone, even without factoring in other industries, will prove materially intensive, and the more rapid and ambitious the transition, the higher the demand (Figure 1.16). Benchmark Minerals suggest that >300 new mines will be required in the next decade to meet demand for batteries alone.[30]

The World Bank estimates that aluminium, copper, and zinc will drive demand, with aluminium (and iron) showing the greatest rise in absolute terms (Figure 1.17).[32] Proportionately, however, the largest increases (of close to 500% by 2050 compared with 2018 production volumes) are expected for minerals used in storage technologies including lithium, graphite and cobalt.[32] The IEA also envisages large increases in demand for these minerals, between 10 (STEPS scenario) to 30 times (SDS scenario) by 2040, with demand by weight dominated by graphite, copper and nickel, and lithium. A critical review of 70 studies assessing global metal demand, finds that demand for all major metals, except lead, is likely to increase continuously this century: based on the median of the data points. The largest growth rate for transition metals in 2050 relative to 2010 was found for aluminium (215%), copper (140%), nickel (140%), and zinc (81%).[20]

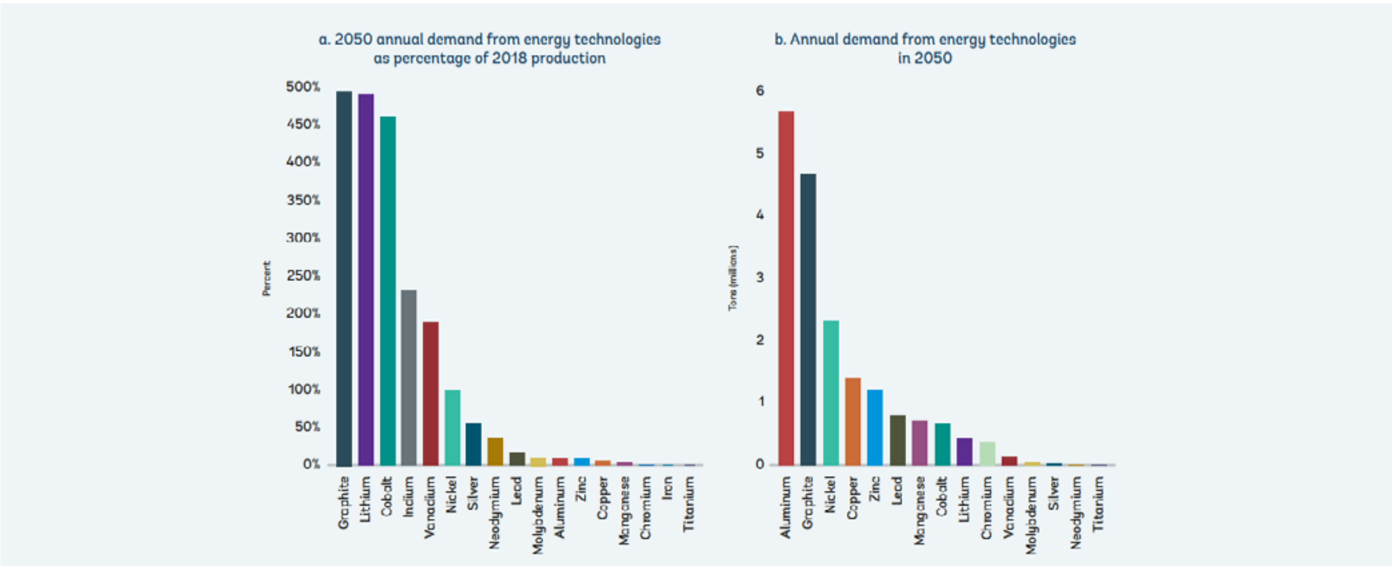



Figure 1.17. Projected Annual Mineral Demand Under IEA's 2DS Only from Energy Technologies in 2050, Compared to 2018 Production Levels. Source: Hund et al (2020).[32]

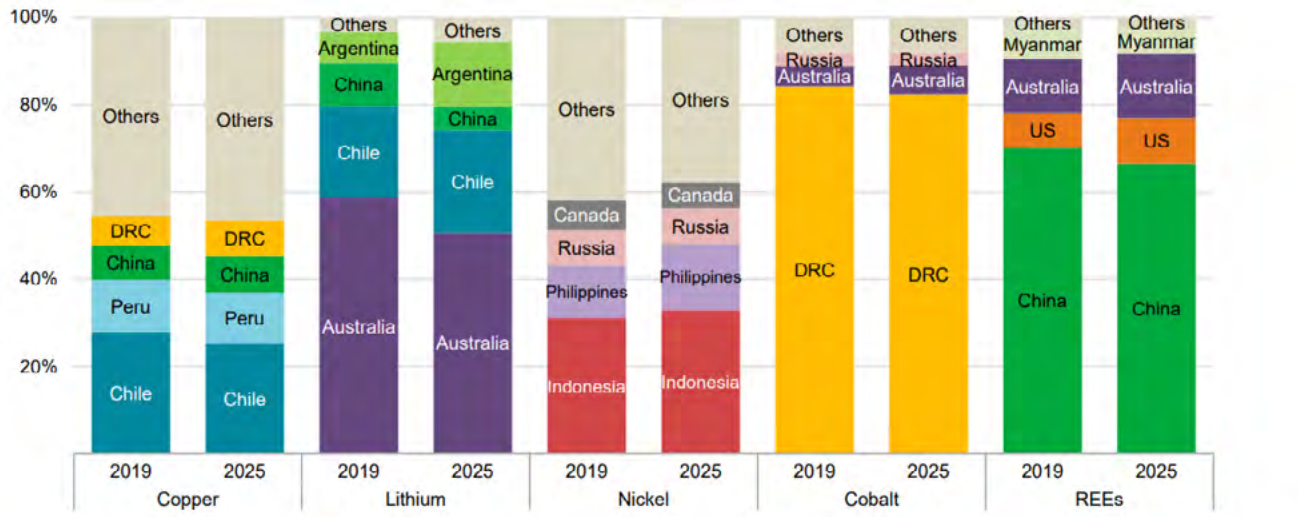
# 1.4. Geography of Projected Growth

**Key Takeaways**

- In the short-term, increases in mining activity will remain concentrated in a few countries.
- In the longer-term, growth in demand for transition minerals will spur greater geographical diversification although this is likely to be broad and shallow (many countries with relatively small production).

## 1.4.1. Established Producers

Growth in global demand for critical transition minerals will not necessarily be matched by geographical diversification of supply, at least in the short-term. The existing concentration of production and processing in a small number of countries is unlikely to change in the near future (see Figure 1.18). This assumption is underpinned by three key indicators: location of known reserves, trends in exploration and current mine construction projects.






Note: Due to the availability of data on projections for future production, REEs here comprise neodymium, praseodymium, terbium and dysprosium only. DRC = Democratic Republic of the Congo; US = United States; Russia = Russian Federation.
Source: IEA analysis based on the project pipeline in S&P Global (2021) complemented by World Bureau of Metal Statistics (2020) and Adamas Intelligence (2020) (for REEs).

*Figure 1.18. Major Producing Countries of Selected Minerals, 2019 and 2025. Source: IEA (2021).[6]*

### Reserves

Key mineral reserves are concentrated in a few countries, suggesting that those same countries will dominate the future supply of critical minerals. For example, 23% of copper reserves and 35% of lithium reserves are in Chile. For Cobalt, 48% of reserves are in the DRC while 90% of platinum reserves are located in South Africa and 21% of nickel reserves in Indonesia.[5] Other countries, especially ones with significant land area such as China, Russia, Australia and the US, hold significant reserves in multiple key minerals. For instance, China has the largest share of reserves for vanadium and REEs, and it also holds more than 5% of the global share of reserves for manganese, graphite, zinc, silver and iron ore.[5]

### Exploration

Exploration budgets have grown in recent years. In 2021, global exploration budgets were $11.2 billion, an increase of 35% on 2020, with the largest expenditure on gold ($6.2 billion) followed by copper ($2.31 billion).[33] Over the last decade gold, copper, lithium and cobalt exploration expenditure for transition minerals has grown significantly (Figure 1.19). IEA report a 30% increase in investment in critical mineral development in 2023, following a 20% increase in 2021, with lithium seeing the sharpest rise (of 50%), followed by copper and nickel.[9]

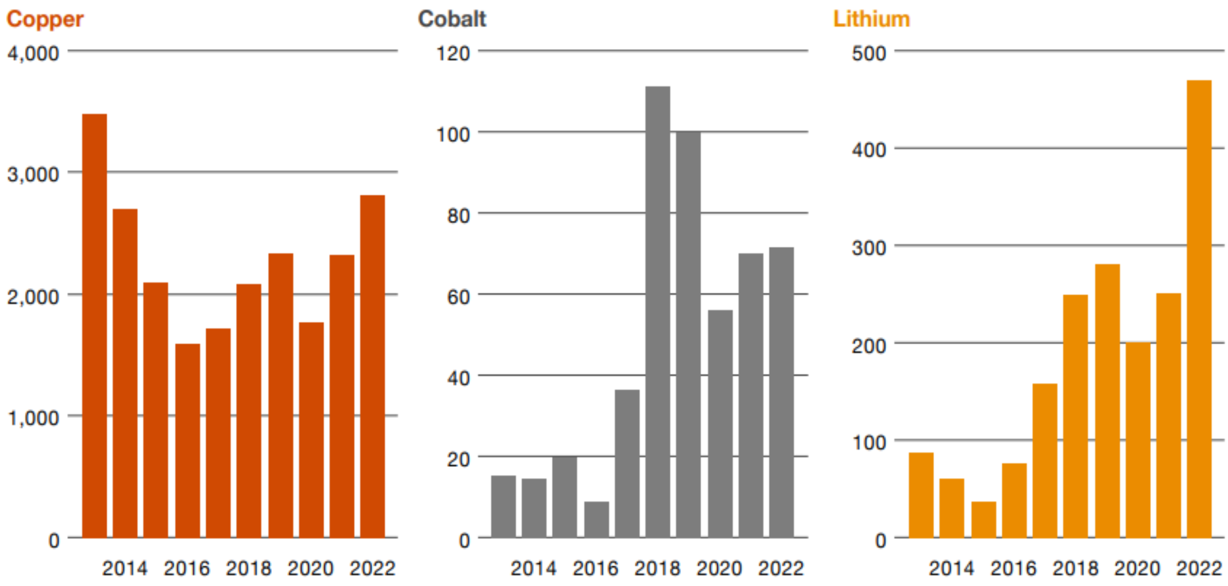



*Figure 1.19. Exploration Spending on Three Key Transition Commodities (US$m). Source: Bermack et al (2023).[34]*

Nevertheless, the same pattern of concentration in a relatively few countries is apparent. Over the last decade, 39% of the exploration budget globally flowed to Canada, Australia and the US.[35] Latin America accounted for 27%, Africa 13% and Pacific-Southeast Asia 4% (Figure 1.20). In percentage terms, these figures have proved fairly constant over the time period.

In 2023, Latin America attracted the largest share of exploration budget at $3.38 billion, led by Chile, Argentina, Colombia and Guyana, dominated by copper, alongside gold and lithium.[36] Canada attracted $2.44 billion (the largest share of any country), followed by Australia at $2.2 billion and the US at $1.62 billion. Africa's budget was $1.27 billion, with countries attracting the highest shares being Guinea and Zambia. Whilst Asia-Pacific is the smallest region by allocation at $370 million, this increased by the largest percentage (9%) of all regions, mainly due to nickel and copper exploration in Indonesia and gold exploration in Fiji.[36]

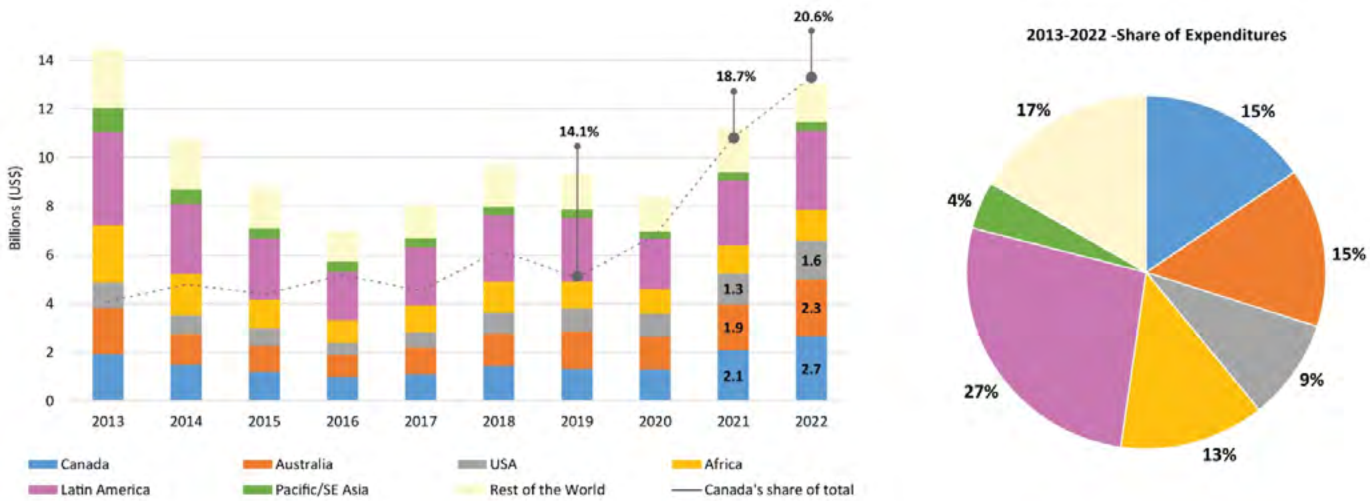



*Figure 1.18. Major Producing Countries of Selected Minerals, 2019 and 2025. Source: IEA (2021).[6]*

### Construction

The outlook for construction mirrors that of exploration, perhaps not surprisingly. In 2023, project activity was forecast to continue an upward trend that has seen project spending increase every year since 2017 (with the exception of 2020).[37] Based on data from Industrial Info's Metals & Minerals Global Market Intelligence, at the end of 2022 there were more than 12,000 active capital and maintenance projects in the mining sector representing US$1.2 trillion, of which 19% are under construction across 2,118 projects, and with a further 4,700 likely to be under construction by the end of 2023.[37] To place this in context, the Global Mine Tracker reports that there are currently >8,000 coal mines,[3] while the Transition Minerals global dataset[38] includes >5,000 active projects.

As with exploration, construction is relatively concentrated. China accounted for US$94 billion of global spending on mine construction in 2023,[37] much of which has been directed towards coal mine construction, with the nation predicted to host one third of all coal mines in the future.[39] The usual suspects follow with Australia spending US$30billion, and the US, Canada and Russia occupying the runners-up slots. India also shows strong activity reflecting its investments in coal production in particular.[37]

In terms of commodities, the picture is dominated by traditional bulk commodities (coal, iron ore) and also copper, gold and silver, although there are signs of increasing investment in the construction of transition mineral projects.[37] In Indonesia, for example, construction has begun on a $2.5 billion nickel mining and processing project.[40] Latin America is also investing heavily ($36 billion) in the construction of mines, much of which is focused in the so-called 'lithium triangle' (Argentina, Chile, Bolivia).[41] However, as the global average lead time from discovery to production is nearly 18 years,[42] supply is still anticipated to continue to lag behind demand.

## 1.4.2. Emerging Producers

If concentration of supply will remain the prevailing narrative in the immediate future, over the longer-term much greater diversification is likely. The biggest numbers can mask smaller developments that accumulate over time with important implications. The demand for transition minerals, created by the related pressures of decarbonisation and supply fears, is driving countries across the world to scour their lands (or seabeds) for these newly significant minerals, whether for reasons of profit or national security or both.

The individual figures for countries may look inconsequential when extrapolated to a global level but they matter greatly when understood from a responsible mining perspective: Many more mines scattered across many more countries, and each significant to those living nearby. Table 1.3 provides an illustrative and non-exhaustive list of countries where select transition minerals are currently being mined.

### Country Case Study 2: Mexico

Mexico's mining industry has grown in recent years with mining production reaching US$16.16 billion in 2022. Approximately half of Mexico's mining production consists of the extraction of precious metals, with the remaining output composed of non-ferrous (40%), metallurgy (6%), and non-metallic (7%) ores.[45] Mexico is the largest global producer of silver as well as a significant producer of gold, zinc and copper. Mining is concentrated in the north of the country in the states of Sonora, Chihuahua, and Durango, though there are mining operations in all Mexican states.[46] As of December 2019, there were 24,066 mining concessions in Mexico, operating in an area equivalent to 8.59% of the national territory.[47]

| Mineral | Top 5 Producing Countries (by 2021 production volume)[1] | Top 5 Reserve Holding Countries (by reserve volume)[2] |
|---|---|---|
| **Lithium** | Australia<br>Chile<br>China<br>Argentina<br>Brazil | Chile<br>Australia<br>Argentina<br>US<br>United States |
| **Nickel** | Indonesia<br>Philippines<br>Russia<br>New Caledonia<br>Australia | Australia<br>Indonesia<br>Brazil<br>Russia<br>Philippines |
| **Cobalt** | DRC<br>Russia<br>Australia<br>Canada<br>Cuba | DRC<br>Australia<br>Indonesia<br>Cuba<br>Philippines |
| **Manganese** | South Africa<br>Gabon<br>Australia<br>China<br>Ghana | South Africa<br>Australia<br>US<br>Ukraine<br>Gabon |
| **Rare Earths** | China<br>US<br>Myanmar<br>Australia<br>Madagascar | China<br>Vietnam<br>Brazil<br>Russia<br>India |

*Table 1.3. Emerging Producers of Selected Transition Minerals*

For some, the mining sector will remain small and will barely register on aggregated, global league tables, while others have already positioned themselves as major players. Mexico and Guinea, for example, have seen rapid growth in recent years (see case studies). For others still, new discoveries may grant them a strategic importance in the race to secure the supply of transition minerals. In Serbia, a decision was recently taken to restore the license to extract lithium in the west of the country, notwithstanding extensive protests. The project could provide as much as 90% of Europe's lithium needs.[43] In Norway, the discovery of Europe's largest proven deposit of REEs provides a critical boost in efforts to diversify supply away from China.[44]


## Country Case Study 3: Guinea

Guinea's mining industry is largely dominated by bauxite production. The country accounts for almost a quarter of global production and holds a quarter of global reserves. Growth of bauxite production has been centred around the Boké region in northwestern Guinea.[48] The majority of Guinean bauxite is exported to China; in 2020, China was the destination for 64% of its bauxite exports.[49] The country also produces iron ore (304,390 tons in 2022)[50] and gold (86,236 kg in 2022).[1] Rio Tinto's Simandou mine project is set to become the largest integrated iron ore mine in Africa.[51]

## 1.5. Challenges and Opportunities Facing the Mining Industry

**Key Takeaways**

- State regulatory and wider governance inconsistencies and failings are the primary obstacle to responsible mining.
- There are more state-based conflicts now than any time since 1946. New demands from global markets for transition minerals contribute to conflict, and transition minerals overlap with states with high levels of corruption and fragility.
- Anxiety over supply deficits and over-dependence on a select few countries will drive demand and diversification but also encourage trade restrictions.
- Long lead times caused by permitting issues, technical challenges, insufficient investment and increasing stakeholder concerns are exacerbating supply bottlenecks.
- However, technological innovation and a growing focus on the circular economy provide real opportunities for the mining sector.

### 1.5.1. Governance

Effective state governance is critical to realising a more socially and environmentally responsible mining sector, both in terms or reducing impacts and in enabling social benefits.[52] In essence, the state plays a "balancing and mediating function by facilitating and promoting mining while also regulating the industry to protect society from environmental and social (and, to a lesser extent, economic) impacts."[53]

To fulfil this function, most countries have existing regulatory frameworks. These generally cover all aspects of mining, ranging from the legal (e.g. licensing), the technical (e.g. geological mapping and mineral exploration), and the fiscal (e.g. royalties and taxes) to the social and environmental (e.g. engagement with affected communities, management of pollution).[54] Where these frameworks function well, mining is more likely to be a net benefit to a country and its people. Recent ICMM research analysing 41 social metrics, grouped under 12 SDGs for mineral-dependent countries, found that the higher the level of the state's governance of natural resources, the stronger the socio-economic progress made.[55]

These regulatory frameworks can vary greatly between jurisdictions in terms of quality, scope and enforcement; and are regularly found wanting.[53] The consequences of poor regulation can be found in more limited protection against environmental and social impacts, greater potential for inequity and conflict amongst local stakeholders, and substantial delays in mine development or even stoppages in production (see section entitled 'Lead Times'). Failures in regulation are compounded by weaknesses in enforcement with even robust regulatory frameworks potentially undermined by poor implementation.[56] The institutions responsible for policing the regulations can be poorly resourced and coordinated or distorted by power imbalances and corruption.[53]

Potential failings in state governance of mining (and indeed other sectors) partly explain the rise and proliferation of alternative frameworks developed by regional, international, and multi-lateral institutions, or corporate partnerships and multi-stakeholder alliances. A non-exhaustive list would include: IFC Performance Standards, OECD Guidelines for Multinational Enterprises, the United Nations Guiding Principles on Business and Human Rights (UNGPs), the Equator Principles, the Extractive Industry Transparency Initiative (EITI), the Global Reporting Initiative (GRI), the Model Mining Development Agreement, the Initiative for Responsible Mining Assurance, the Natural Resource Charter, and Africa Mining Vision.

While each of these is distinct in substance, scope, or focus, they all share the same aim of improving corporate governance of social and environmental issues and are all borne, to an extent at least, of the same underlying problem: weaknesses and inconsistencies in some states' willingness or capacity to regulate the private sector, including the natural resource sector.

The principal flaw with these frameworks is that they are, broadly speaking, non-binding. Each has carrots and sticks but there is no real substitute for the state's power to set comprehensive standards and hold companies to account if they fall short. Within the mining sector specifically, two common problems illustrate this problem, one at the beginning and one at the end of the mining lifecycle, while the extent and scale of the governance challenge is also demonstrated by including the informal mining sector - or Artisanal and Small-scale Mining (ASM, see Box 1).

Licenses for exploration are typically awarded without requiring a permitting process or consultation with local stakeholders. These safeguards only tend to become relevant once minerals have been discovered.[57] While the impacts of exploration may be limited, these early stages can be critical to setting the tone of local stakeholder relations for subsequent mine development.[58] As such, there is a real value to identifying and consulting with rightsholders prior to exploration. Similarly, although expectations of what Environmental and Social Impact Assessments (ESIAs) should contain are clearly defined through international frameworks (e.g. IFC Performance Standards,[59] EBRD Requirements and Guidance)[60] these expectations are insufficiently or inconsistently applied or, since many ESIAs are conducted prior to lender financing, are often carried out to less stringent host government standards.

**Box 1. Governance and ASM**

ASM refers to "mining by individuals, groups, families or cooperatives with minimal or no mechanisation, often in the informal (illegal) sector of the market."[61] ASM is a major contributor to global mineral supply chains. For example, it accounts for about 20% of global gold, 26% of global tantalum and 25% of tin production.[62] Furthermore, 8% of global bauxite and 10% of global cobalt production is not reported and considered as artisanal and small-scale.[63] In recent decades, ASM is thought to have contributed to 15-20% of global non-fuel mineral production overall.[61]

Regulatory shortcomings at the level of ASM are considerable. Despite ASM's vast contribution in terms of global workforce and mineral supply, continued informality in the sector perpetuates harmful socio-economic, health and environmental impacts, and frequently traps ASM workers in a cycle of poverty. This makes workers and their families particularly vulnerable to corruption and criminality,[62] exposing them to hazardous working conditions, and depriving them of the right to access legal protection or support services.[65] Formalisation of ASM would require governments to develop ASM-specific legal, policy and regulatory frameworks, a huge undertaking that would challenge the most sophisticated states let alone those already struggling with resource and capacity issues.

At the other end of the lifecycle, similar problems are evident in mine closure. Many governments lack the necessary regulations and capacity to manage closure and post-closure transition. For example, some governments require only high-level plans with limited detail, often reviewed by staff without the necessary expertise, unclear accountability, or with insufficient capacity to respond. Others, meanwhile, provide no guidance to companies on what should be included, how it will be reviewed, or how this is factored into permitting.[66] In an IGF survey of governments to assess mine closure readiness, 14% did not require any form of assurance (and only 45% required that the full amount of the estimated closure cost is secured through financial assurance), and 75% did not keep a record of the companies who had surrendered their leases.[66] When mine closure is poorly managed the result is often extensive environmental and social impacts, leaving governments and affected communities to shoulder the costs.[67]

### 1.5.2. Corruption, Instability and Conflict

The strategic importance of the mining sector as well as its scale in terms of social and environmental impacts make it especially vulnerable to failings in state governance. In countries where there is political instability and weak governance, mineral extraction is more likely to be associated with (or accompanied by) violence, conflict and human rights abuses.[68] As Figure 1.21 shows, countries with significant reserves of transition minerals are also often those with middle to high measures of fragility and corruption. For example, Guinea, a highly fragile state, is home to 28% of global bauxite reserves while 48% of cobalt reserves are in the DRC (Table 1.4). More generally, most transition minerals overlap with high levels of corruption, with 100% of chromium and graphite reserves found in states considered corrupt or very corrupt in the Corruption Perception Index.[68]

The confluence of mineral reserves and corruption emphasises the importance of transparency.[56] ICMM research found that developing countries with lower levels of corruption, and an active civil society, such as Chile and Botswana, are better able to translate natural resource wealth into sustained social benefits.[55] Tellingly, most of the countries found to be closing the social and economic development gap in non-MDCs are EITI member countries, such as Ghana, Indonesia and Peru.[52,55]

The corruption risks associated with the mining sector are likely to increase as demand for raw materials increases. Past commodity booms have led to a corresponding increase in corruption incidence. With new players entering the market and reserves concentrated in countries that score poorly in Transparency International's Corruption Perceptions Index, there is a pressing need for all actors in the supply chain to work to address these issues.[69]

As noted by the UN Office of the High Commissioner on Human Rights, corruption has a destructive effect on state capacity, including their ability to respect, protect and fulfil human rights, with a particular negative impact on marginalized or vulnerable groups.[70] Corruption robs the state of funds to provide essential infrastructure and services, such as healthcare and education, and undermines the functioning of oversight institutions and the rule of law. Corruption causes significant harm in and of itself, yet it is also a key enabler of other harms addressed in this report.

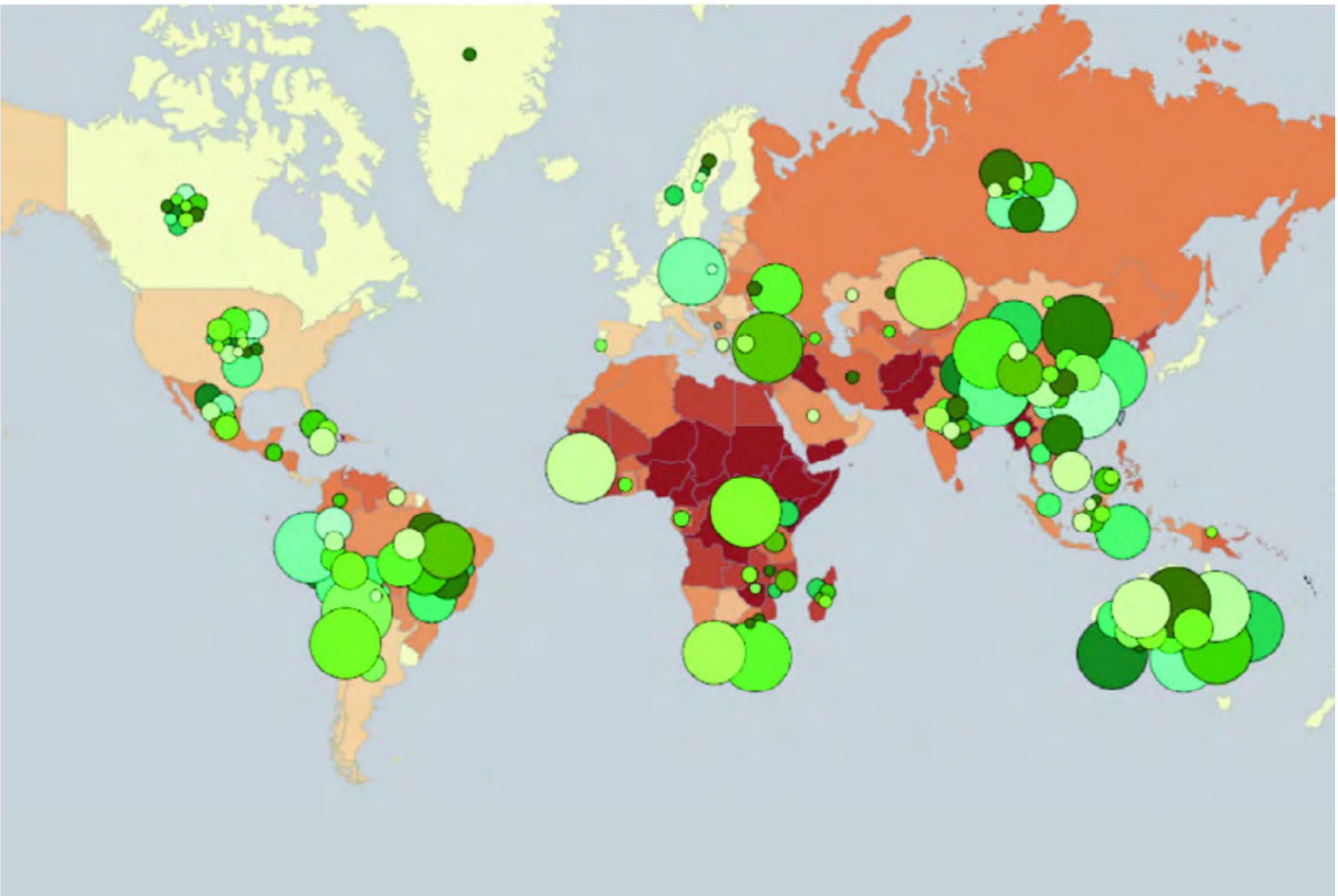


*Figure 1.21. Global Reserves of Minerals Required for "Green energy Technologies" Overlaid with Fragility and Corruption Measures. Source: Church & Crawford (2020).*[68]

| Mineral | Global reserves located in a fragile or very fragile state[a] (%) | Global reserves located in states perceived to be corrupt or very corrupt[b] (%) |
|---|---|---|
| Bauxite and Alumina | 44 | 68 |
| Chromium | 55 | 100 |
| Cobalt | 70 | 70 |
| Copper | 41 | 41 |
| Graphite | 73 | 100 |
| Iron | 42 | 60 |
| Lead | 49 | 49 |
| Lithium | 21 | 34 |
| Manganese | 66 | 86 |
| Molybdenum | 70 | 72 |
| Nickel | 42 | 59 |
| Rare Earths | 58 | 94 |
| Selenium | 76 | 76 |
| Silver | 52 | 52 |
| Tellurium | 67 | 67 |
| Tin | 69 | 84 |
| Titanium | 57 | 62 |
| Zinc | 52 | 59 |

*Source* Fund for Peace (2018), Transparency International (2017), U.S. Geological Survey (2018)

[a]Labelled as "elevated warning," "high warning," "alert," "high alert," or "very high alert" on the 2018 *Fragile States Index*: receiving a score of 70.00 or higher (113.4 is the highest score, held by South Sudan).

[b]Receiving a score of 43.00 or lower on the 2017 *Corruption Perceptions Index*. A score of 1 denotes a highly corrupt state; a score of 100 denotes a very clean state.

*Table 1.4. Mineral Reserves in States with High Fragility and High Corruption. Source: Church & Crawford (2020).*[68]

In addition to overlap of a number of mineral reserves with fragile states, a range of minerals are sourced from conflict-affected and high-risk areas (Box 2). In 2023, the Uppsala Conflict Data Program (UCDP) recorded the highest number of state-based conflict since 1946.[71] Drivers of conflict are growing, catalysed by increasing global pressures over resources, climate change, technological advances in communications, artificial intelligence and weapons systems, radicalised belief and political systems, and also new demands from global markets including for transition minerals. The latter is already contributing to conflict in areas of instability. Amidst a trend of growing conflict and increasing pressures, mining in fragile states and conflict-affected areas is a growing challenge.

**Box 2. Definition of Conflict-Affected and High-Risk Areas**

The EU Conflict Mineral regulation defines "conflict-affected or high-risk" areas as those "whose natural resources include minerals which are in high demand, either locally, regionally of globally" and "are either suffering from armed-conflict, such as civil war, a state of fragile post-conflict, or witnessing weak or non-existing governance and systematic violations of international law, including human rights abuses."[72]

The OECD definition is "Areas identified by the presence of armed conflict, widespread violence, including violence generated by criminal networks, or other risks of serious and widespread harm to people. Armed conflict may take a variety of forms, such as a conflict of international or non-international character, which may involve two or more states, or may consist of wars of liberation, or insurgencies, civil wars. High-risk areas are those where there is a high risk of conflict or of widespread or serious abuses as defined in paragraph 1 of Annex II of the Guidance. Such areas are often characterised by political instability or repression, institutional weakness, insecurity, collapse of civil infrastructure, widespread violence and violations of national or international law."[73]

## 1.5.3. Security of Supply

As discussed in section 1.3, uncertainty surrounds projected demand for all minerals, with the demand for transition minerals especially unpredictable. There are too many variables to allow for accurate forecasts. These include innovations in the efficiency of mineral extraction; in battery design and manufacturing (e.g. early commercialisation of vanadium-flow batteries), or in recycling; the pace of uptake of renewable energy technologies; and political instability linked to mounting global geopolitical tensions and resource nationalisation.

In theory, difficulties in estimating demand make the prediction of supply needs challenging. In practice, however, other forces will dictate assumed supply needs for transition minerals, at least in the short-medium term. Net zero targets that depend upon a huge expansion in renewable energy have been sold to consumers on environmental and financial grounds. Supply shortages will not only drive prices up, and thereby push consumers back towards fossil fuels, but will also constrain the rate of renewable energy technology manufacturing. Without the minerals, the batteries, solar panels and wind turbines can't be built, and the targets can't be met[6] (Figure 1.22).

Although any supply gap is likely to catalyse innovation (e.g. through application of circular principles), this will likely be insufficient.[74] Moreover, even those states that are cynical or ambivalent about climate targets and renewable energy recognise the potential strategic importance of these transition minerals across multiple technologies, and few will gamble on missing out. In short, demand will be driven by insecurity of supply in part stemming from anxiety over a supply deficit, at least in the near future.

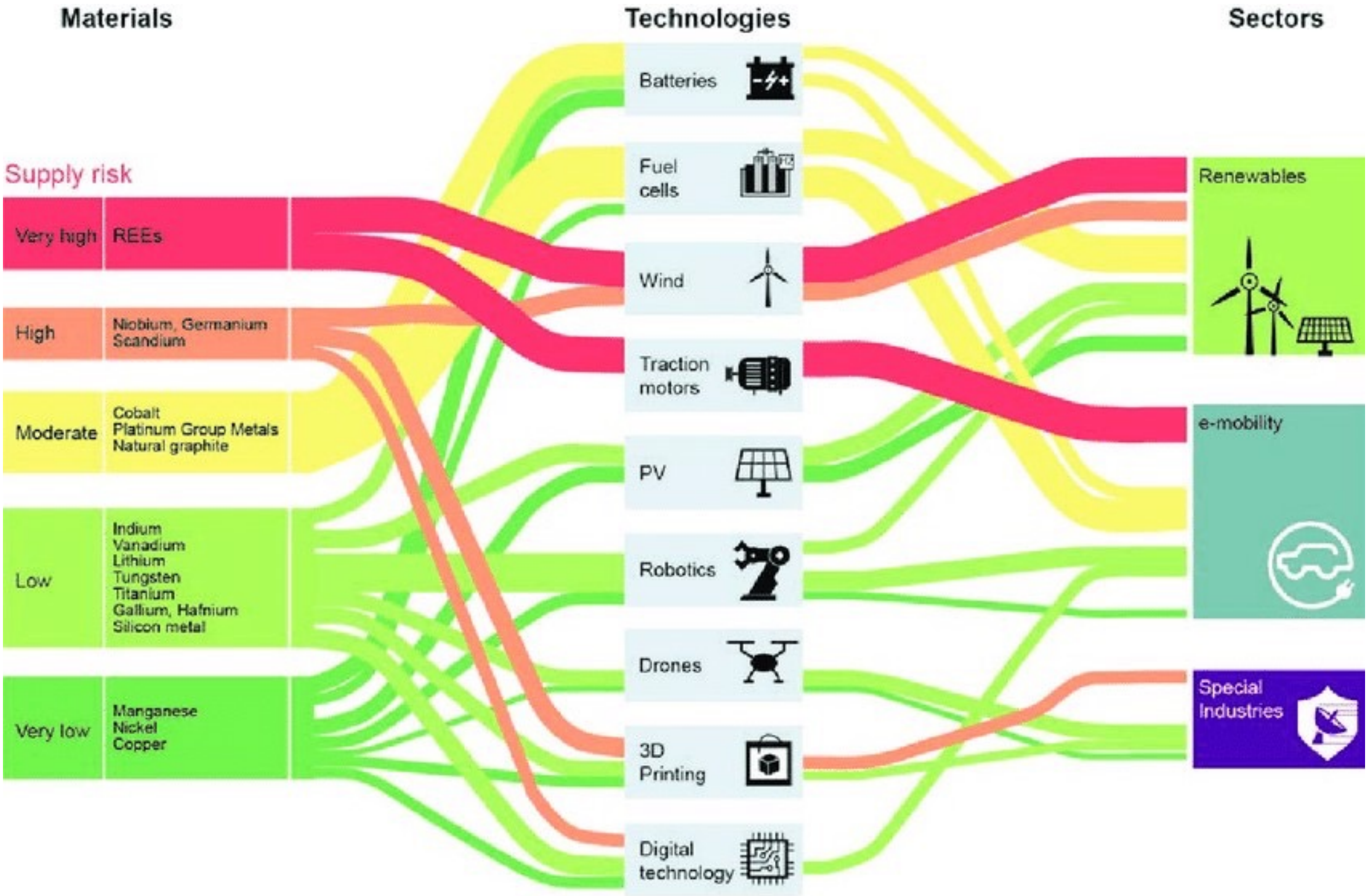



*Figure 1.22. Supply Risk of Raw Materials Needed in the Clean Energy Transition. Source: Eilu et al (2021).[75]*

Part of this anxiety is caused by the relative concentration of transition minerals in a few countries, often those with high-risk profiles. Commodity markets with a diverse range of sources tend to be more resilient. However, there is currently limited diversity in either the production, or especially the processing, of transition minerals (See Section 1.4). China dominates the production of REEs and the processing of lithium, similarly the DRC in the production of cobalt (see Country Case Study 4). A recent analysis of six key minerals found that production of lithium, cobalt, iron ore and bauxite is particularly concentrated, with >70% of global supply sourced from no more than three countries for each mineral (Figure 1.23). Further, 81% of the lithium, 50% bauxite and 44% iron produced globally is sourced from just ten mines.[76]

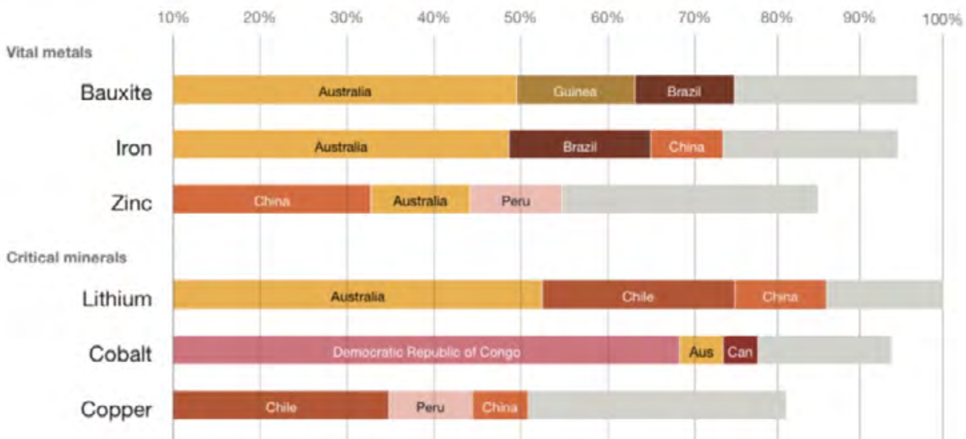



*Figure 1.23. Share of Global Production 2020. Source: PWC 2024 (grey represents remaining top 10 producers of the commodity). Source: PwC (2024).[76]*

## Country Case Study 4: DRC's Cobalt Industry

The DRC produces almost 70% of the world's cobalt.[77,78] Artisanal and Small-scale (ASM) mining is estimated to account for 10-30% of this production annually.[79] With cobalt demand expected to double by 2030 relative to 2022, the DRC will deliver a significant portion of this projected growth[80] and is certain to cement its position as the dominant source of cobalt.

However, the DRC also ranks highly on other league tables: state fragility, weak governance, conflict, corruption, human rights abuses, and environmental damage. In addition, the prevalence of ASM, while offering a vital source of income for many,[81] is linked to forced[82] and child labour [83] and carries significant health and safety risks. Mining activities in the DRC have fuelled conflict as illegal armed groups vie over mineral resource rents, and profits are used in turn to fund arms.[77,84] It is claimed that Burundi, Rwanda and Uganda have each profited from the DRC's insecure situation by exchanging weapons, money, training, intelligence and logistical support to rebel groups in the DRC for minerals to launder into global supply chains.[85]

The risks of this level of dependence are manifold. The DRC's continued and growing strategic value will only intensify competition for its resources, encourage states to turn a blind eye to abuses or environmental harm, incentivise criminal gangs to control the informal mining sector, and breed even higher levels of corruption. Arguably, the DRC's dominant status in cobalt production is not only bad for the world's security of supply, but also for the country itself.

Although mining contributes 30% of GDP and is a major employer, mining is also a key driver of deforestation in the DRC.[86] Cobalt mining has resulted in extensive water and air pollution, with negative impacts on ecosystem health,[87] and severe health impacts on surrounding communities.[88] For example, in areas surrounding copper-cobalt mines, levels of toxic pollutants in food crops and drinking water have been found which far exceed safe limits.89,90,91 This has been linked to exposure-related oxidative DNA damage[92] and high prevalence of rare birth defects.[93] Exposure to cobalt dust has also led to incidences of a fatal condition known as "hard metal lung disease"[94,95]. Authorities recently halted cobalt mining operations (owned by ERG-owned Boss Mining) as a result of tailing dam overflow that caused substantial damage to the environment and loss of life.[96]

DRC's mining industry is governed by the Mining Code, established in 2002 and revised in 2018. The revised Code has increased taxes on strategic minerals (including cobalt), includes a community development royalty of 0.3% and a 10% royalty payment to be paid into a sovereign mining fund dedicated to future generations, and requires that companies establish a provision of 0.5% of turnover for mine rehabilitation[97]. It requires mining companies to craft 'Terms of Reference' in consultation with affected communities.[98] However, complex national and provincial politics and corruption have hampered robust implementation of mining laws.[99-102]

The problem of supply concentration is exacerbated by trade restrictions. The number of export restrictions on critical minerals globally has increased five-fold in the last 15 years.[103] For example, since the 2000s, Argentina, Bolivia and Chile have enacted regulations to control lithium assets.[104] In 2020, Indonesia banned export of raw nickel to promote development of its domestic processing industry, a move that is being challenged in lawsuit from the EU.[105] In December 2022, Zimbabwe prohibited raw lithium exports.[85]

At a global level, China's dominance in production and processing, and its increasing resource nationalism, is seen as the biggest threat to supply. In 2023, China placed export restrictions on several transition minerals, including gallium, germanium and graphite. The restrictions on graphite, of which China controls 65% of production, is having a significant impact on EV production in the US.[106] In December 2023, China banned the export of technologies for processing REEs, another mineral group where it exercises strong control.[107] China also has a large share of global solar PV and lithium-ion battery manufacture,[103] accounts for 75% of battery and EV manufacturing,[103] and is the largest market for these technologies.[108] China also owns, or has significant shares in, mining industry assets, having issued over $170 billion in debt across 1,200 loans to African governments and state-owned mining operations.[85]

Some countries have responded by developing their own critical mineral strategies to promote security of supply and are pushing to "onshore" or "friend-shore" mineral supplies. While understandable, this potentially encourages further resource nationalisation and creates more fragmented supply chains.[74] For example, the EU's (2008) Raw Materials policy and strategy aims to boost a sustainable domestic supply, as well as improve resource efficiency and supply of secondary raw materials through recycling.[109] The EU Battery Alliance aims to source 80% of Europe's lithium needs from within the EU.[110] The United States has introduced the Minerals Security Partnership, and the Inflation Reduction Act to promote domestic production and production in nations with which it has free-trade agreements.[74]

Insecurity of supply has already triggered diversification in some minerals, as demonstrated by the expansion of REE production in the US, Myanmar and Australia, resulting in China's global share falling from 95% to 60%.[111,6,112] In contrast, lithium and cobalt offer limited opportunities for diversification.[103] Significant lithium production is occurring in Australia (52%), Chile (24%) and China (13%),[113] while lithium refining is dominated by China (59%). The DRC's pre-eminence in cobalt production is discussed above although it is worth adding that China refines 69% of global cobalt production.

The situation is not helped by depleting reserves and declining ore grades for certain minerals. For example, the largest copper mine globally, Escondida in Chile, has passed peak production[6] and copper ore grades globally have declined by 25% in the last ten years.[114] Declining ore grades are making extraction and processing more expensive, more energy intensive, and increasing tailings waste.[115] Over the next ten years, the energy demand in Chilean copper mines is expected to increase by 41% as a result of declining ore grades and increased mineral depth.[116] This problem is exacerbated by rising demand for battery-grade minerals.9 Declining high grade iron ore deposits in developed nations is also reducing diversity in supply, shifting focus to developing and less politically stable countries.

## Country Case Study 5: Geopolitical Tensions shaping Russia's Mining Industry

Due to sanctions on imports of oil and gas by Western countries in response to Russia's war in Ukraine, Russia has shifted its focus towards the mineral sector. Thanks to its integration in global value chains, the Russian mineral sector poses a challenge for sanctions. As a result, Russia views this sector as holding strategic value both economically and politically as a means of retaliation against sanctioning countries, with Western countries' dependence on Russian minerals making them vulnerable to counter-sanctions.[117] For example, an embargo or a slowdown in the export of palladium would have a minimal financial impact on the Russian state — palladium accounts for just 0.43% of domestic GDP — but would cause a major shock to the Western car industry and disrupt global markets.[117]

Russia is increasingly looking towards Asian markets which have not imposed sanctions while abandoning projects oriented towards Western markets. such as the construction of port infrastructure for the transhipment of coal to Murmansk.[117] Russia is also turning its attention towards mineral production in Africa.[117] For example, Russian state-owned mining company Alrosa has become well established in Angola, Zimbabwe and, more recently, the DRC, while Rusal, Russia's largest alumina producer, has expanded its bauxite operations in Guinea.[118]

A key challenge for Russia's mining industry is its outdated and derelict infrastructure, especially its transportation networks. Much of the country's rail, bridges and ports have not been updated since the Soviet era, making it challenging to connect mineral production to national and international markets.[117] Current sanctions on Russia are preventing the import of machinery and equipment necessary for the expansion and modernisation of Russia's mining industry, hindering progress on social and environmental impacts.[117] The country's current isolation from international investors and industrial groups is also likely to inhibit innovation, potentially slowing production and increasing future production costs.[117]

### 1.5.4. Lead Times

In 2023, the global average lead time for a new mine to go from discovery to production was just under 17 years.[42] In 2024, S&P Global reported that this has continued to increase, reaching an average of 17.9 years, compared to 12.9 years fifteen years ago.[119] For example, copper and nickel projects have typically taken 7–8 years to move from feasibility to production and can take over 20 years in certain cases when earlier stages of exploration and development stages are included in the timeframe.[120] For nickel, this has been due to a doubling of the time taken to complete feasibility assessments.[120] Lithium projects, which are typically smaller scale, can often be developed in 4-7 years.[120]

Other pressures influencing lead times include: fluctuating commodity prices, the small size of some newly discovered reserves, a lack of financing and technology, bottlenecks in the resources required, a restrictive policy environment and broader macroeconomic factors (e.g. high taxation and inflation). Long lead times on new mining projects are limiting the extent to which mining companies can fulfil rising global demand,[xii] particularly in the short to medium-term.

Xii The period between when exploration activities begin, and mining production starts.

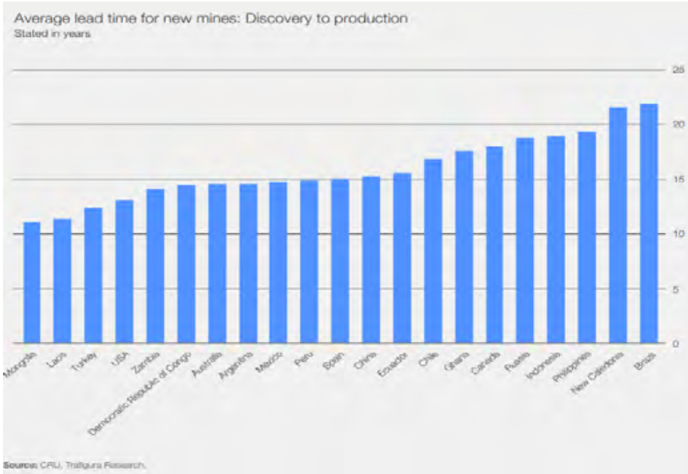



*Figure 1.24. How Long Major Mines Take From Discovery to Production. Source: World Economic Forum (2023).[74]*

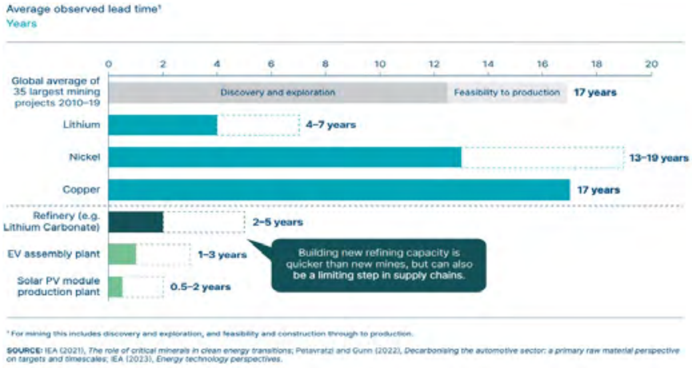



*Figure 1.25. Lead Times for Transition Minerals. Source: Energy Transitions Commission (2023).[120]*

Recent analysis of over 100 transition mineral projects has shown that over the last six years almost 60% of projects reported pre-production delays ranging from a few months to several years, with projects citing ‘permitting issues’ (39.4%) and ‘technical challenges’ (36.4%).[58] Although ‘environmental concerns’ and ‘stakeholder opposition’ were only cited as the primary cause of delays by 24.2% and 16.7% of projects respectively (Figure 1.26), 62% of the projects delayed by permitting issues were reported to be due to stakeholder opposition or concerns around the project’s environmental impacts. In many of these instances, stakeholder concerns around environmental impacts had not been factored into project design, with public consultations and, in some cases, a re-design of the project, causing costly delays later in the process.[58]

Nevertheless, for governments and investors eager for revenues or to turn a profit, and mine managers with tight schedules and limited budgets, a focus on environmental and social performance can often feel like an unaffordable luxury. This is particularly true in a wider landscape in which other companies and investors with lower ESG expectations may be seen as more competitive, and therefore better placed to win mining concessions. However, the undoubted costs (in time and money) of extensive stakeholder engagement and rigorous environmental management need to be set against the long-term benefits, not just in terms of the sustainability of the local area, but the mine itself.

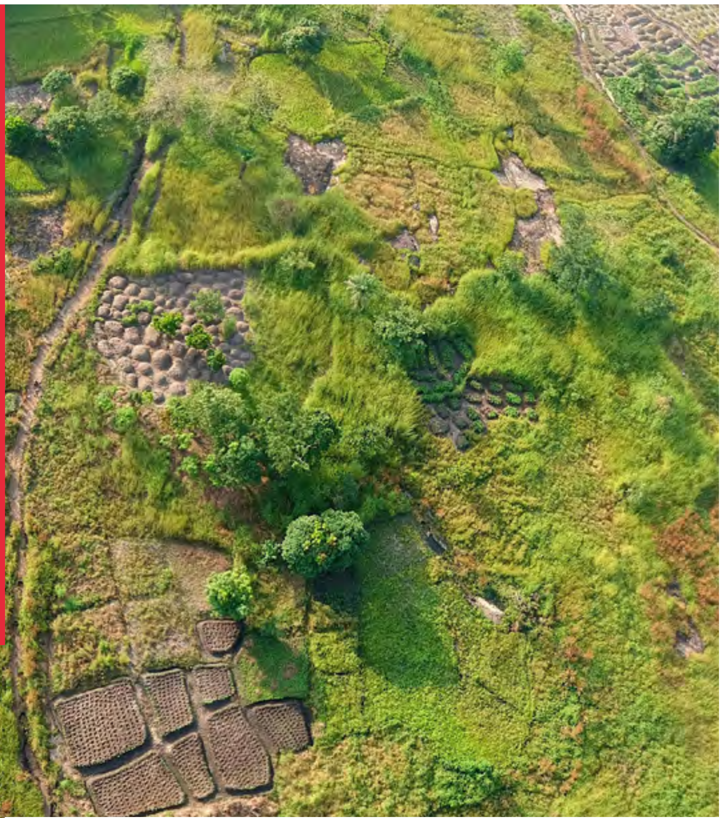
There is increasing evidence demonstrating that strong ESG standards help create resilience and long-term business success, in addition to improving investment returns. This means companies with robust ESG credentials can outperform peers and the wider market.[121,122] For example, research has shown that companies with good social engagement practices were less likely to experience extensive planning or operational delays, in turn achieving demonstrably higher valuations than competitors with lower social capital.[123]

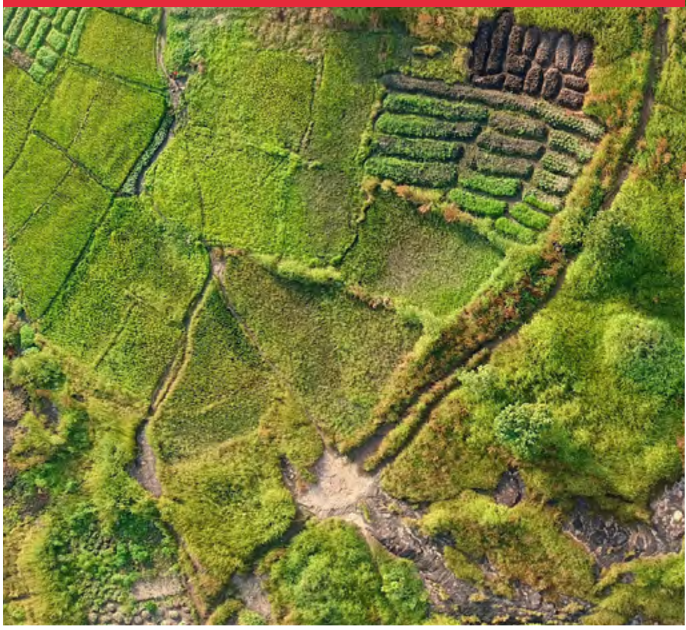
**Box 3. Labour and Skills Shortages**

Another factor in long lead times is skills shortages. In a 2022 survey of senior mining leaders, the majority reported that a talent shortage is impacting their ability to meet production targets and strategic objectives, and that this problem has become more acute in the last two years.[124] This shortage is reported as particularly acute in Australia, Canada and the US.[125] In these areas, this has been linked to general labour scarcity in combination with increased demand for minerals, the poor reputation of the sector, an aging workforce, failure to attract women and migrant employees, competition from other highly skilled industries, employees looking for a wider range of incentives than a good salary (e.g. flexible working), and the isolation of working at mine sites.[126,127]

## Country Case Study 6: Simandou Mine in Guinea

One example highlighting the impact of pre-production delays is Rio Tinto's Simandou project in Guinea. Political instability over recent decades has impeded the supply of minerals from Guinea, resulting in a reluctance to invest in the country's mining projects.[51] The Simandou mine (the world's largest iron ore project) has experienced 27 years of setbacks caused by legal issues, corruption and operational challenges in part due to the political turmoil affecting the country.[i] Since a government coup in 2021, Guinea has been controlled by a military junta and the intensification of anti-government protests suggests instability is likely to continue. [128]





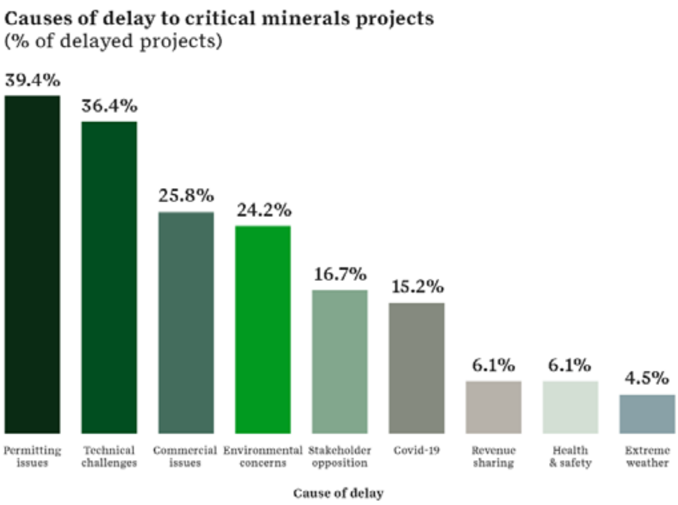



*Figure 1.26. Reasons Cited for Long Lead Times. Source: Whincup et al (2023).[58]*

### 1.5.5. Gaps in Investment

Increased capital expenditure by companies on developing transition mineral supply is needed to cut costs and accelerate the speed of transition. The IEA estimated that if all planned 'critical mineral' projects were to go ahead, supply could meet the Announced Pledges Scenario. This is a hopeful scenario to say the least, and is likely to be undermined by long lead times and shortfalls in funding.

To meet the material and resource requirements for the clean energy transition, the Energy Transitions Commission estimate that capital investments in six key energy transition metals (lithium, nickel, graphite, cobalt, neodymium and copper) need to rise from $45bn/year to an estimated $70bn/year through to 2030.[120] The cumulative investment required to meet demand for the minerals up to 2050 is between $1.1 to $1.7 trillion (depending on the demand scenario used). Of this $480–750 billion is for mining (Figure 1.27) and around two-thirds is needed in the next ten years to enable the significant increase in production implied by the demand scenarios (Figure 1.28)[120]. Even more ambitiously, Wood MacKenzie estimates that the industry needs to invest a cumulative US$1.7 trillion from 2020 to 2035 to meet the demand profile of their Accelerated Energy Transition (AET-2) scenario, compared with investment of around US$600 billion across the five commodities included in the analysis over the previous 15 years (Figure 1.28).[129]

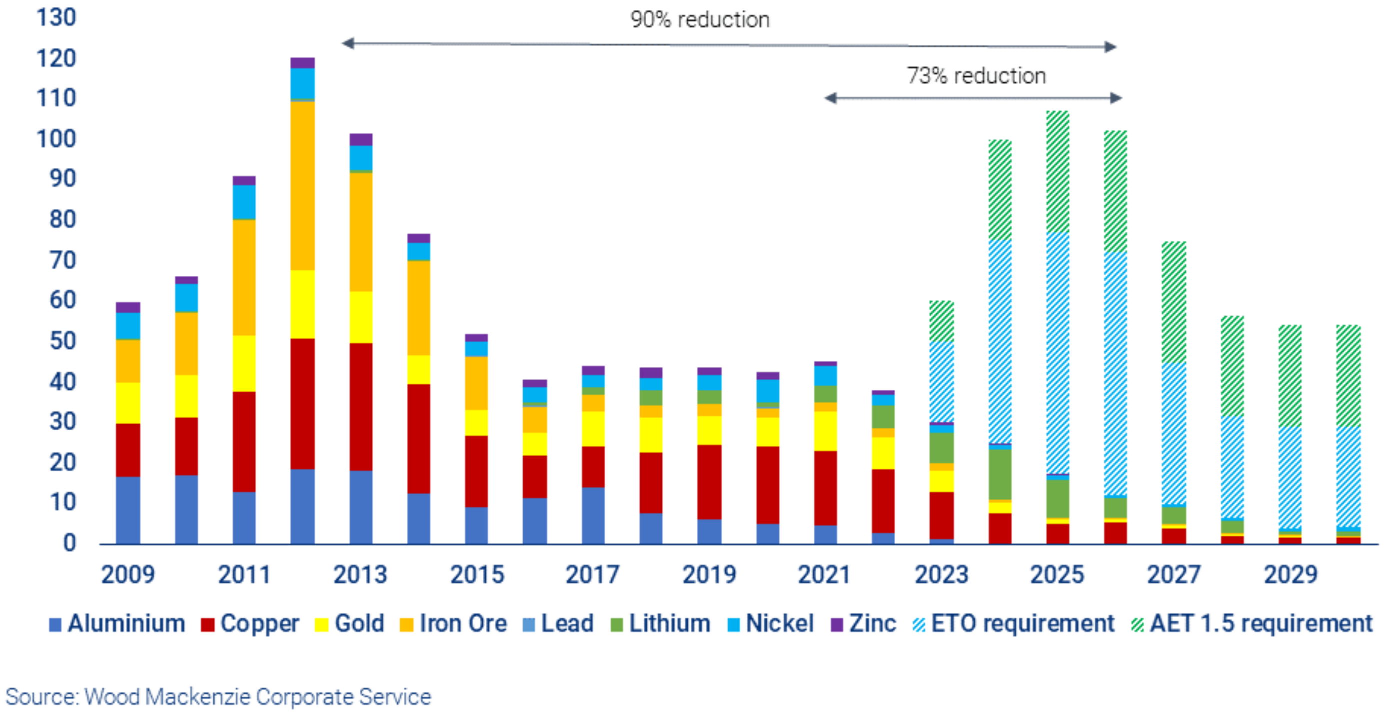



*Figure 1.27. Metals and Mining Committed Investment CapEx and Requirements (US$bn). Source: Wood Mackenzie (2022).*[130]

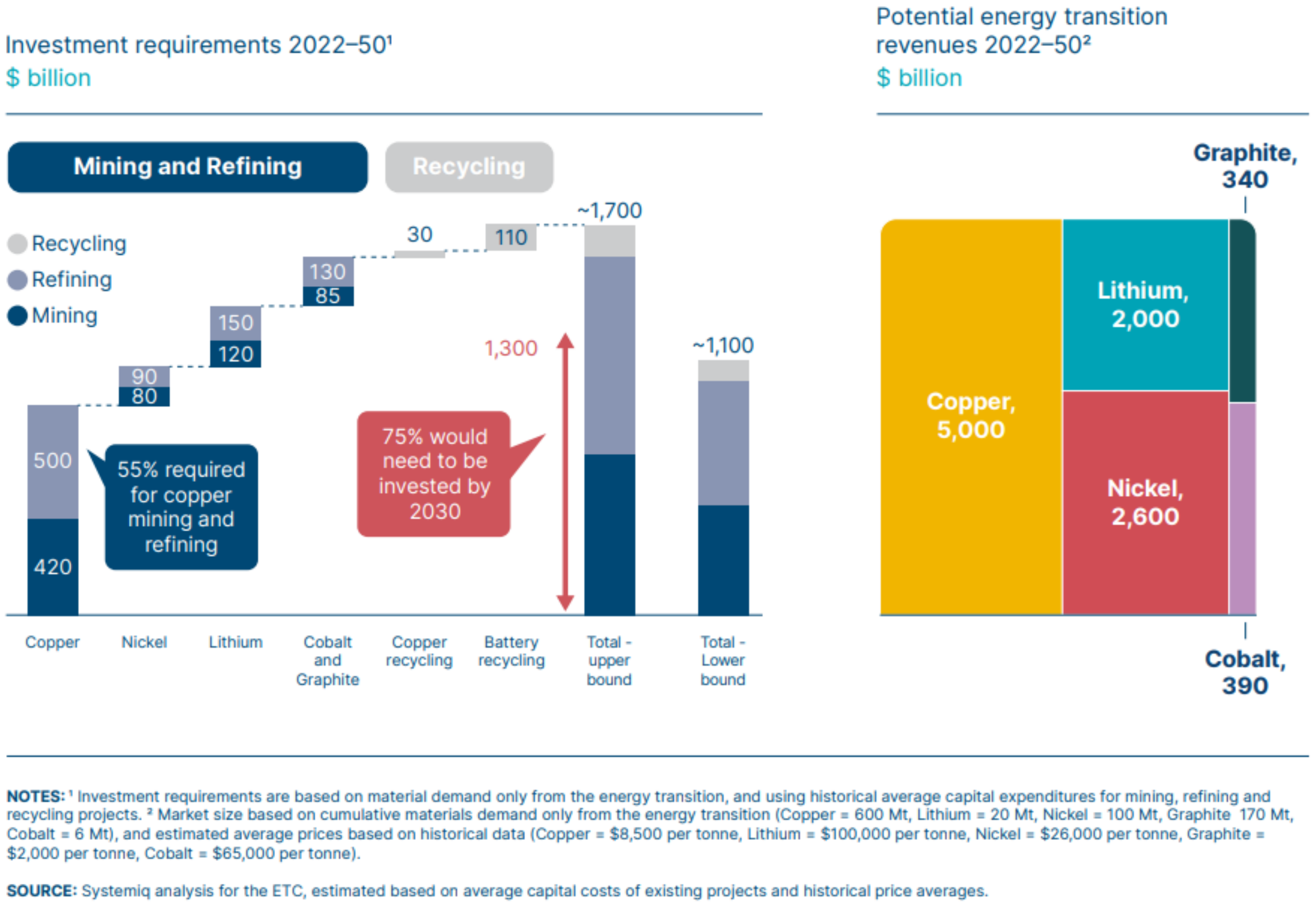



*Figure 1.28. Investment Requirements 2022-2050 to Unlock Potential Transition Revenues 2022-50. Source: Energy Transitions Commission (2023, p75).*[120]

## 1.5.6. Technological Innovation

Rapid shifts in technological innovation are both an opportunity (e.g. improving efficiencies in extraction) and a challenge (e.g. rapidly changing demand for certain minerals and metals).[56] Technology is likely to transform supply and demand dynamics with potentially significant implications globally, alongside possible negative social impacts, for example reduced job creation and local procurement of goods and services (i.e. by employees).[56]

Automation, using robotics technologies, has already changed operations from exploration to processing and refining, and it is likely that this trend will continue.[56] One study, completed in 2020, estimated that automation could lead to around 10,000 coal mining jobs (approximately 40% of Queensland's coal mining workforce) being lost in Queensland, Australia.[131] This is expected to reduce employment opportunities in the industry, and also has income (including tax) implications, both of which are positive contributions that are key to the sector's social license to operate.[132] In addition, automation will represent a shift in skills required, likely to a smaller but more highly skilled workforce. The potential higher wages of a few numbers of highly skilled (potentially expatriate) workers in contrast with lower wages of low-skilled workers, may contribute to widening inequality in mining areas.[132]

## 1.5.7. Climate Change

Mining's relationship to climate change is double-edged: part problem, part solution.

Climate change's relationship to mining is less ambiguous; it poses risks: through damage to mining infrastructure and assets as a result of extreme weather and sea level rises (for coastal operations) - affecting production, access and transportation. Extreme weather was cited as the cause of long lead times in mine development in nearly 5% of cases (see Figure 1.26). It is safe to assume this number will increase as the effects of climate change become more pronounced.

The two principal threats are flooding and drought. Flooding in particular increases the risk of failure of critical pieces of infrastructure, such as tailings storage facilities and pit walls, particularly those built in the past based on design criteria which did not consider extreme weather events. To adapt those critical facilities to a changing weather is going to prove a major challenge. For example, McKinsey reports 10% annual production losses in one open-pit coal mine as a result of wet weather alone.[133] Based on MineSpans data, McKinsey consider iron ore and zinc to be the mineral commodities most exposed to high flood occurrence at an estimated 50% of iron ore and 40% of zinc operations.[133]

Drought is of particular concern in relation to several transition minerals, notably lithium, cobalt and copper. Of the three, lithium is perhaps the most vulnerable given its dependence on water with two million tonnes of water required to mine one tonne of lithium.[76] A recent PWC analysis (2024) found that even in a 'low emission scenario' in 2050, 74% lithium and cobalt and 54% copper production is exposed to Significant (20% of time in severe drought), High (40% of time) or Extreme (80% of time) drought risk (Figure 1.29).[76] In Chile, for example, 80% of copper production is already located in extremely high water-stressed and arid areas; by 2040, it will be 100%.

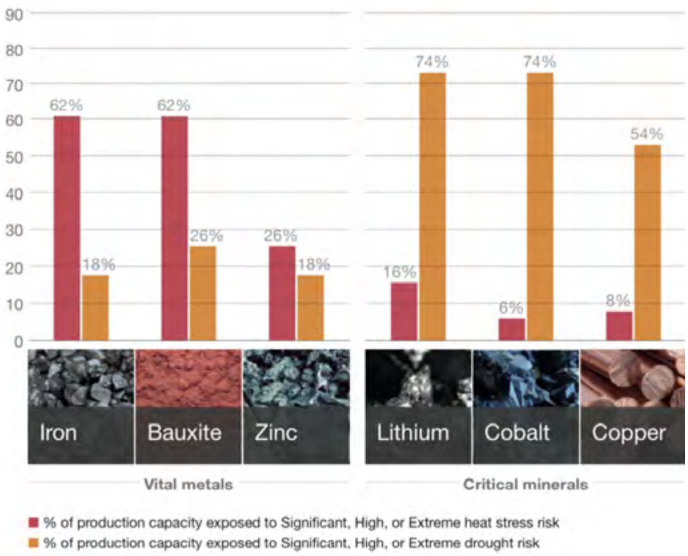



*Figure 1.29. Low Emissions Scenario 2050. Source: PWC (2024).[76]*

## 1.5.8. Circular Economy

Circular economy strategies are estimated to have the potential to reduce mining demand for cobalt, copper, lithium, and nickel by 25-55% of total demand by 2040.[108] These estimates are based on uncertain projections of future mineral demand, but circularity in mining operations and within mineral-dependent value chains is nevertheless a huge opportunity for meeting demand, managing supply chain disruption, and reducing the social and environmental impacts of mining.

**Box 4. What is the Circular Economy?**

The circular economy is defined as, "A system where materials never become waste and nature is regenerated. In a circular economy, products and materials are kept in circulation through processes like maintenance, reuse, refurbishment, remanufacture, recycling, and composting. The circular economy tackles climate change and other global challenges, like biodiversity loss, waste, and pollution, by decoupling economic activity from the consumption of finite resources."[134]

It is based on three principles of design:

- Elimination of waste and pollution;
- Circulation of products and materials at their highest value;
- Regeneration of nature.

UNEP have identified 9Rs of circularity, being Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle and Recover (Figure 1.30). Regeneration can also be added to this list and is pertinent to the mining sector both in terms of regenerating nature on, or in proximity to mine sites, and in the restoration of closed mining operations.

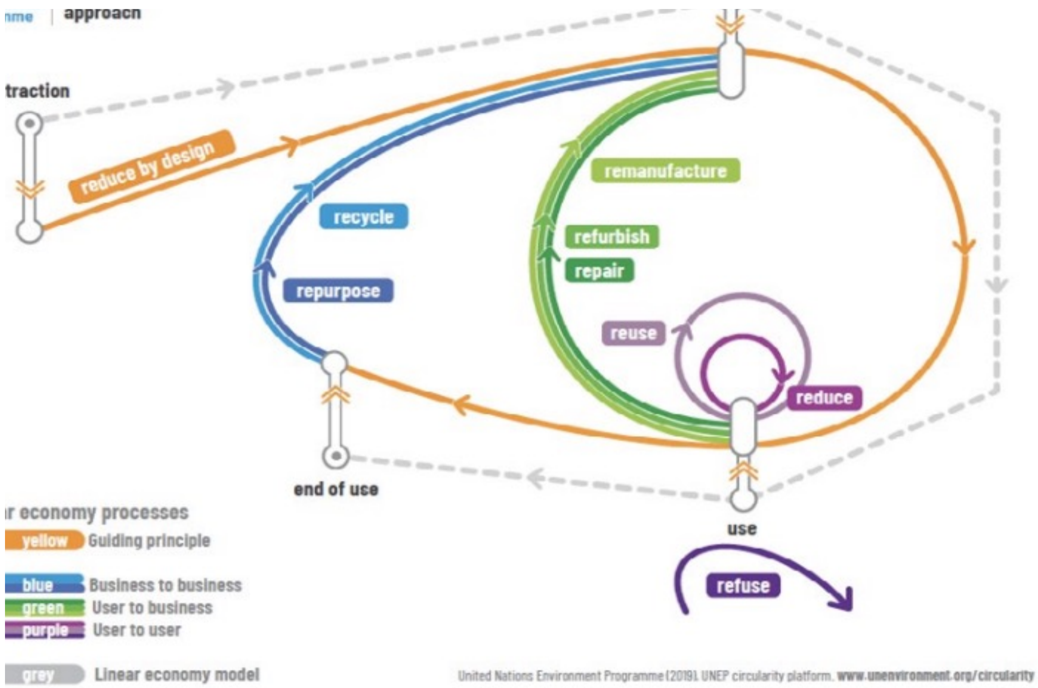
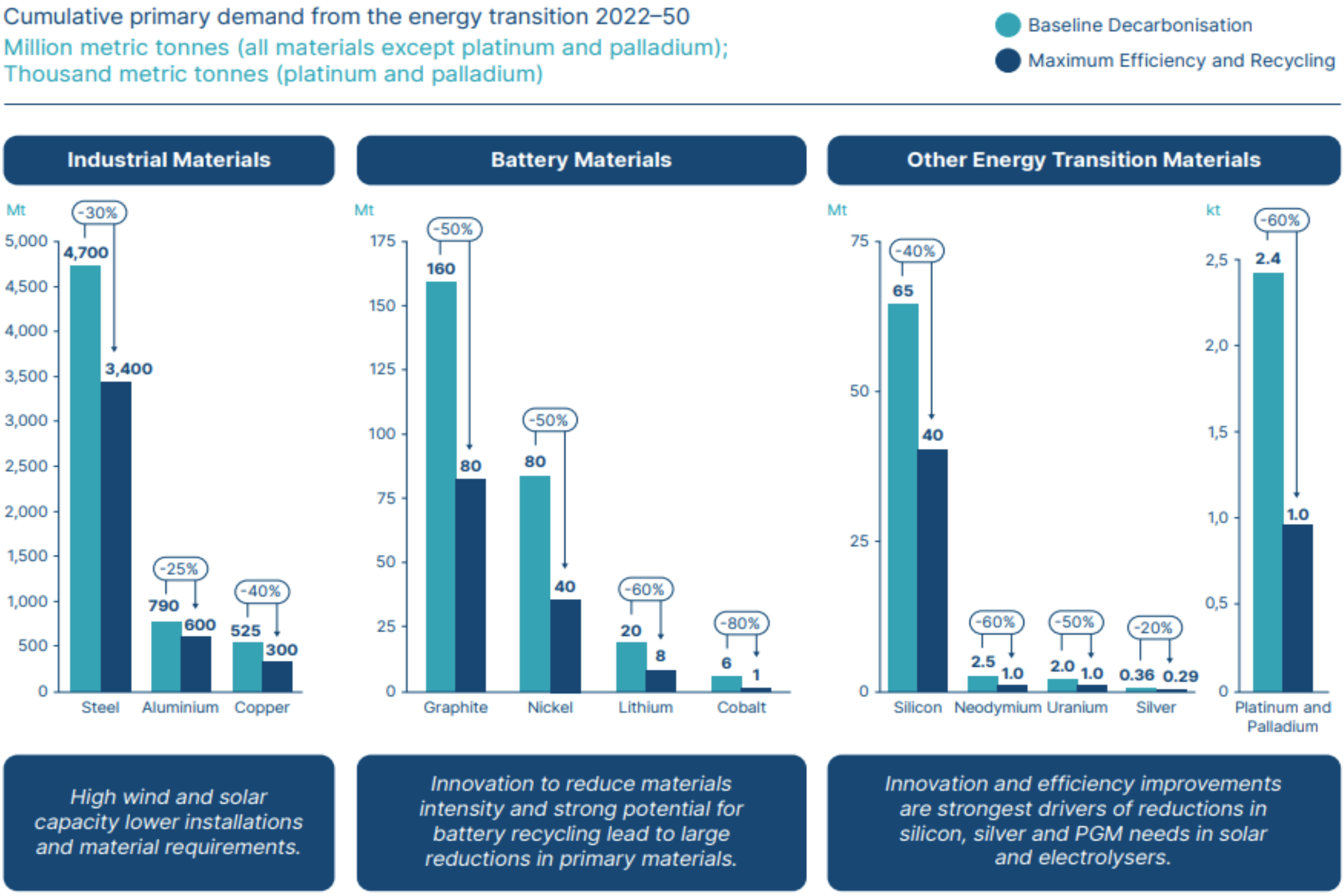



*Figure 1.30. UNEP's Circularity Approach. Source: UNEP-FI (2023).[135]*

In the short term (up to 2030), the solutions with the most impact involve improving materials and technology efficiencies, reducing the volumes of primary minerals required and helping to reduce gaps between supply and demand.[120] Mid-term (post-2030), next-generation technologies and expanded recycling can start to have impact in reducing primary demand for minerals. However, secondary supply of recycled minerals would only start to have a significant impact in meeting demand post-2030.[120] Combining maximum efficiency and recycling could reduce demand for primary extraction by 2050 by nearly 30% for steel, 25% for aluminium, 40% for copper, 80% for cobalt, 60% for nickel, 55% for lithium, nearly 50% for graphite, and between 20-60% for other energy transition materials (Figure 1.31).[120]




**NOTE:** The ETC's Baseline Decarbonisation scenario assumes an aggressive deployment of clean energy technologies for global decarbonisation by mid-century, but materials intensity and recycling trends follow recent patterns. The Maximum Efficiency and Recycling scenario assumes accelerated progress in material and technology efficiency, and recycling of clean energy technologies/materials, thereby reducing requirements for the primary (i.e., mined) supply of materials.

**SOURCE:** Systemiq analysis for the ETC.

*Figure 1.31. Cumulative Demand from the Energy Transition 2022-2050 Against Baseline Decarbonisation and with Maximum Efficiency and Recycling. Source: ETC (2023).[120]*

### Country Case Study 7: Canada Flags Role of Circular Economy to Meet Transition Mineral Demand

Several countries, such as Chile, India, EU states, US and Canada, are increasingly recognising the importance of a more circular economy in ensuring secure supply of transition minerals.

The Canadian Critical Minerals Strategy recognises the importance of the circular economy in the clean energy transition[136]. In particular, the Strategy highlights the opportunities for the recycling of tailings waste, with $10 billion worth of total metal value in Canadian gold mine waste alone[137]. Consequently, Natural Resources Canada began the 'Mining Value from Waste Initiative', which seeks to "develop and apply processes and technologies (from concept to demonstration) to extract value and reduce liability from tailings, by recovering valuable metals and using the wastes as resources in other applications."[138] The Electronic Product Stewardship Canada is also promoting e-waste recycling of gold, palladium, silver, and copper[139,140]

The mining sector is already considered advanced in certain areas of innovation that reduce impacts and simultaneously advance 'unconscious' circularity. For example:

- reducing water use through closed loop recycling, evaporation prevention, and dry tailings;[141]
- reducing waste through precision mining and repurposing tailings for new products;[142-145]
- developing capacities for recycling and recirculating metals;[141] and
- taking action to restore nature in land under mining stewardship.[141]

There is potential for the mining sector to go further, delivering on 'conscious' circularity within the broader value chain. These include designing for durability and product lifetime extension, re-use and re-manufacturing, using less material and eliminating waste, recycling, and promoting sharing business models (Table 1.5).

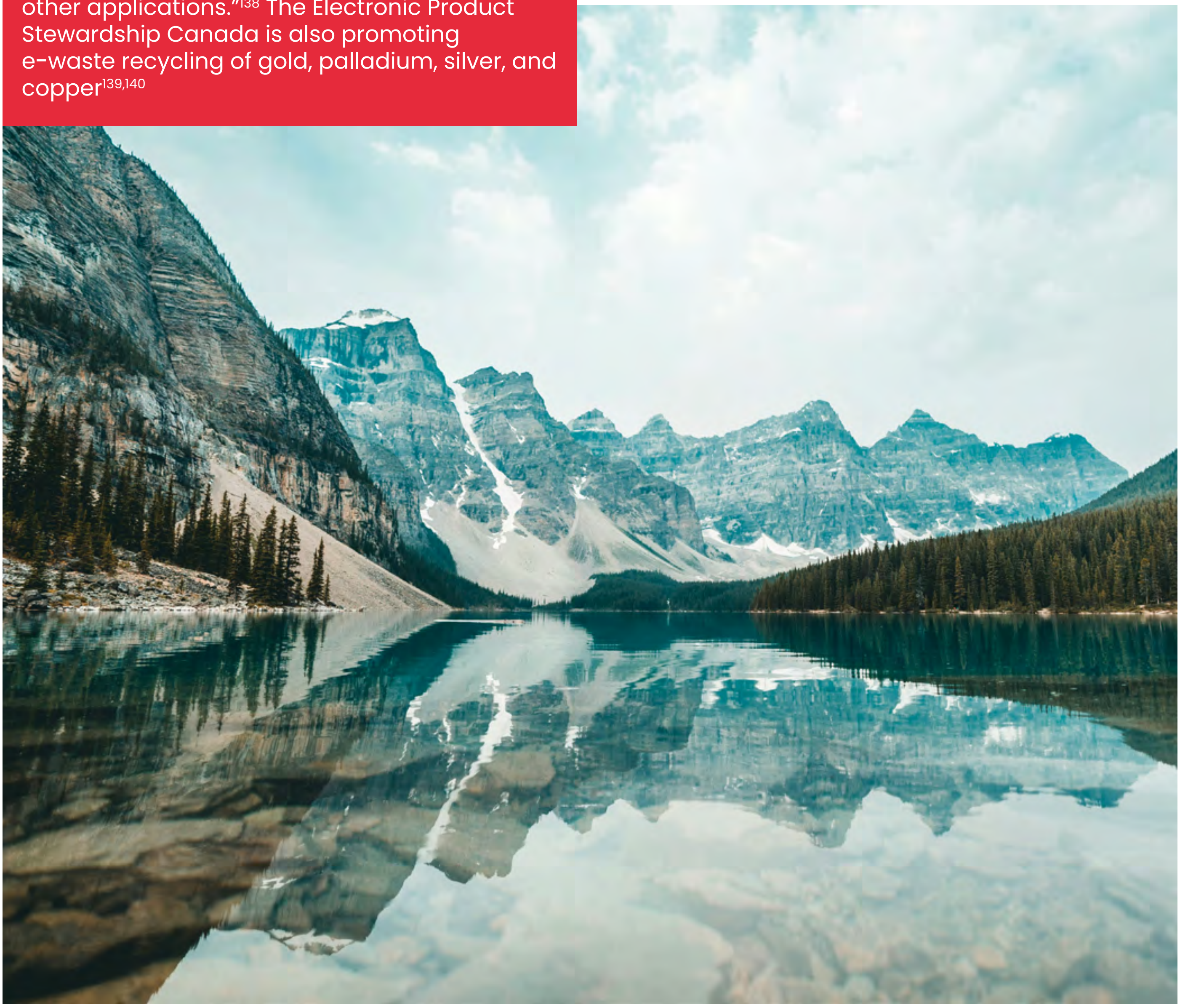


*Table 1.5: Potential Innovations Organised by R-Strategies of Circularity*

| R-Strategy | Actions |
|---|---|
| **Refuse** | Downstream industries can source minerals only from mines, refineries and recycling operations operating at expected social and environmental standards, and that are shifting away from coal-powered extraction and processing. Similarly, mining companies can take a more proactive role in demanding that their customers (including government procurement) align with, and uphold, the expected responsible sourcing standards across all their procurement. |
| **Reduce** | Manufacturers can reduce demand for primary minerals by **using secondary minerals** where possible.<br><br>**Improving efficiency** of renewable energy technologies (i.e. improved performance, reduced mineral intensity and substitution with alternative materials) has been estimated to provide significant reductions in mineral demand, and crucially in supply gaps for many critical minerals, including for example:[120]<br><br>- 25% reduction in steel demand by 2050 due to reduced needs from wind and solar installations;<br>- 20% reduction in aluminium use in overhead cabling and mountings for solar panels by 2050;<br>- 30% reduction in demand for copper by 2050 due to reduced use in grids, a reduced build-out of wind and solar installations, and lower copper intensity in EVs;<br>- 40% reduction in lithium demand by 2050 due to a shift to sodium-ion batteries (post-2030), improved battery energy density, and slowed growth in battery pack size.<br><br>**Intentional design to reduce materials used and eliminate waste.** For example, for batteries and other emerging waste streams, a high proportion of scrap results from the production process (i.e. >90% of total scrap availability in the next five years); it is anticipated that this will reduce as manufacturers use minerals more efficiently as production increases.[63] Design with the intention of reducing waste and using fewer materials requires enhanced knowledge among all stakeholders involved in the design and construction of products, but is currently a limiting factor within the construction industry.[146] |
| **Rethink** | **Service-based business models** (e.g. accessible rental schemes for EVs) can also be encouraged to enable more efficient use of products such as vehicles and buildings.[120] Manufacturers retaining ownership of product, also increases prospects for re-use, repair, re-manufacturing and recycling. This business model goes beyond manufacturing, adding a new service. For example, a rental model has been established by Renault for the lithium-ion batteries used in its EVs, allowing the batteries to be repurposed when users return them.[147] |
| **Repair and Refurbish** | **Design for durability and product lifetime extension** can reduce demand for primary extraction. For example enabling replacement of components can enable vehicle fleets to last up to 10 times longer.[148] This includes avoiding products becoming obsolete with new technological developments, new trends, or due to incompatible hardware and updated software.[149] Durability requires manufacturers and other downstream users to move to a more modular build approach that allows for components to be removed and replaced, identifying other opportunities for components to be re-deployed,[150] and connecting manufacturers with spare part suppliers to enable timely and stable distribution of the necessary parts.[151,152] Ensuring the right to repair for products helps to keep them in circulation at their highest value for longer.[153,154] To date, cost and accessibility of spare parts has deterred repair relative to buying an updated model,[153] though this might change with the EU and UK recently introducing right to repair legislation. For example, Apple, has established a self-service repair scheme alongside Apple Authorised Service Providers with access to the necessary tools, parts and manuals.[155] Similarly, refurbishment of used products can restore their quality to as good as new but often enable them to be marketed more cheaply.[156] Some companies offer refurbished products, but consumer awareness of and confidence in refurbished products generally is still low. |
| **Re-purpose and Re-manufacture** | **Intentional design for re-use and re-manufacturing** enables technologies to be easily re-deployed in new capacities. For example, EV batteries lose storage capacity over time but can be re-deployed in capacities requiring less power, e.g. electronics, data centres.[147] Promoting re-use of EV batteries requires expansion of initiatives to give batteries a second life at competitive prices.[157] |
| **Recover** | **Recover minerals from other existing sources.** For example, an estimated 460 Mt of copper is already in use[158], including 30 Mt that could be recovered from fossil fuel-powered power plants as they are decommissioned.[120] This can also involve re-use of by-products. For example, 82% of the steel company ArcelorMittal's production residues were reused or recycled as by-products in 2022, but only 8.7% by-products at the company's mine sites were re-used[159] To further improve recovery and re-use in the steel sector requires technical advances to improve the quality of by-products recovered. |

| | |
|---|---|
| Recycle | **Recycling end-of-life products to recover metals** is common practice in many commodity markets.[63] However, they can be difficult to extract and recycling rates are variable, e.g. total recovery rates for cobalt are only 30%, while the EU, which is a leader in e-waste, only collects and recycles 35% of electronic products.[160]<br><br>**Intentional design for decommissioning and recycling is needed, including consideration of the infrastructure and systems required.** Some companies are already advancing plans to recycle materials, for example Honda anticipates recovering 80% of rare earths in some of their used nickel metal-hydride car batteries[157] while Siemens is already recycling rare earths from its EVs.[161]<br><br>Mineral value chain actors can improve recycling rates through design of products and components to facilitate disassembly and separation, investing in recycling infrastructure, **creating recycling pathways** making it easy for owners, dealers, and repair shops to return batteries to manufacturers at the end of battery life;[157] **standardising batteries** (e.g. shape, size, labelling) to make recycling less dependent on company-specific recycling programs;[157] **establishing standards for first and second battery life[157]** and **assurance schemes to ensure quality** of recycled materials; and **funding research** into recycling of composite materials, improve efficiencies and lower costs of recycling processes.[162,120] In addition to facilitating the above, governments can also provide more certainty around the pace and scale of transition to clean energy, and therefore the minerals required, in turn incentivising investment in efficiencies and recycling;[120] take action to address fragmented and informal collection and sorting systems with limited coordination between various actors within the value chain;[152,63,120,163] |

## 1.5.9. Mining Legacy

Legacy issues do not necessarily only occur at the end of a mine's life, but may arise, for example, following a change of owner or in company policies, during the operational stages of a mine. As such, we can consider two categories of legacy: historic legacy and operational legacy. Operational legacy issues may be inherited during mergers and acquisitions, also known as legacy or successor liabilities. These may include, for instance, legacy of poor relationships, potential legal action, or environmental damage. At the point of acquisition, it is vital to ensure the due diligence to identify legacy issues is carried out and then to ensure that there are sufficient resources and capacity to manage and mitigate the impacts and avoid further issues in the future. In 2023, a surge in mergers and acquisitions in the sector, reflecting a decade-long trend of consolidation in the industry, was reported. This suggests addressing legacy impacts during the operational stage of a mine may be a growing challenge.

Historic legacy is an umbrella term that typically (albeit variably) refers to "previously mined, abandoned, orphan, derelict or neglected" mine sites and waste storage facilities.[164] Orphaned refers to those for which the owner cannot be found, while abandoned sites are those whose owner is known but unable or unwilling to address the problems.[165] Globally there are millions of legacy sites[166] with "almost all" mining countries having "legacy sites that pose a risk to environment and/or public safety."[167]. Although there is limited documentation of legacy sites globally, Australia is reported to have more than 50,000.[164] Moreover, amongst a survey distributed to ICMM members, 40% of the operations managed by members that responded are expected to close over the next 25 years, and 20% in the next 10 years.[168]

Historic mining legacies can be a threat to public health, the environment, socio-economic health and sustainability, and culture, varying with the size of the legacy and the severity of impacts. [164]

Many governments do not have the necessary policies, regulations, enforcement, or capacity to manage mine closures and post-closure transitions effectively.[66] Many governments also do not require companies to provide full financial assurance and do not maintain records of the companies who surrender leases.[66] Yet when mine closure is poorly managed, this can result in extensive environmental and social impacts, with the, often substantial costs, falling to governments.[67] With closure costs increasing, how closure is undertaken and legacies managed is critically important, requiring preparation and strategic thinking to ensure prosperous post-mining economies and healthier local ecosystems.

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# 2. Impacts of the Mining Industry

Mining is indispensable to modern society. It provides the raw materials for many of the industries on which we all rely, from food production to construction, transportation, communications and beyond. Its importance has become even more pronounced as the enabler of the renewable energy technologies required to achieve global climate targets. A sector long criticised for its environmental damage, is now fundamental to a greener economy.

The mining industry has always worked to balance its positive and negative impacts. At a local level, few industries create and sustain so many jobs, directly as part of the workforce and indirectly through local procurement. Few industries have the resources to deliver vital shared infrastructure and such potential to bring growth and prosperity to surrounding regions, while contributing to national economies through royalties and taxes.

The mining sector is also improving practices to reduce negative impacts. When not done well, landscapes can be degraded, livelihoods upended, rights abused, conflicts generated and communities displaced. Conflict and corruption are also associated with mining activities in certain states, which can reduce the advantages of mining locally and nationally.

There are opportunities for the mining industry to raise the bar across all regions. Just as companies contribute most when acting in concert with others, so the challenge of delivering a more consistently responsible mining sector is one that requires the support and contribution of all those with a stake in mining. Thus, the finance industry's role is important in shaping the future of the industry.

## 2.1. Mining Contribution

**Key Takeaways**

- Mining plays an indispensable role in the global economy and is fundamental to enabling the transition to renewable energy.
- Under the right circumstances, mining is and can be a major driver of growth and development.
- Directly and indirectly, mining is a valuable source of employment, especially in developing countries.
- At local and regional levels, mining-related infrastructure and local procurement is an important enabler of economic development.

Given the right circumstances, mining can make positive contributions to society at international, national and local levels. Globally, mining is indispensable to many of the industries on which we all rely, from food production to construction, transportation and communications. Mining may underpin as much as 45% of the global economy when both its direct contribution and its contribution to other industries are considered.[1] The persistent, and often unfair, image of mining as the world economy's dirty secret is undergoing a transformation. The clean energy technologies required to achieve global climate targets are built with the minerals and metals the sector extracts.

At a national level, mineral extraction plays a principal role in the economies of 81 countries representing half of the world's population and almost 70% of those living in extreme poverty.[2] Mining accounts for over 50% of exports and 10-20% of GDP in some nations. This is particularly true in African and Latin American nations, many of which are low- and middle-income economies (Figure 2.1).[3,4] 63 of the 72 countries classified as low or middle-income countries in 2019, are projected to increase their reliance on extractive industries (oil, gas and mining) for growth in the next 20 years.[5]

Many mineral-rich, low- and middle- income countries have undergone sustained economic growth fuelled by the export of mined commodities. A World Bank analysis shows that countries rich in minerals have experienced marked improvement in the Human Development Index (HDI) scores that are, on average, better than for countries without minerals. Interestingly, this rapid growth occurred with no clear pattern of worsening inequality or deteriorating governance.[7] Notably, the countries with strong or improving governance indicators, including those with close oversight of the mining sector, seem to have had an even faster average growth rate (see Case Study 6).[7] For example, one of the most mineral-dependent countries in Sub-Saharan Africa, Botswana, has been one of the fastest growing economies globally with the highest HDI in the region. Similarly, Chile is the most mineral dependent country in South America and one of the fastest growing economies with the highest HDI score in the region.[7]


*Figure 2.1. Mining Contribution Index (MCI-W) Score by Country, 2018. Source: ICMM (2018).[6]*

## Case Study 6. Peruvian Legislation Promotes Mining Contribution (see also Case Study 10)

Mining plays an important role within the eruvian economy. It accounts for roughly 10% of government revenue and 8.3% of GDP in 20238, with mineral exports representing about 64% of Peru's total exports.9 Mining investment is also the largest source of foreign direct investment (FDI) in the country.[7] Mining activity is regulated primarily through the General Mining Law adopted in 1992 with the aim of establishing industrial mining as a key pillar of economic growth.9 Peru's mining licence allocation procedure has been praised for its simplicity, transparency, non-discretional nature, accessibility and for the legal certainty it provides.[9]

All mining companies pay the standard corporate income tax along with royalties which are distributed to provinces. Therefore 20% is received by the relevant provincial government and 20% by the local governments of the districts in which the mining occurs, of which 50% goes to the local communities located near to the mine.[10] This system helps ensure that areas most impacted by mining receive a share of the benefits, and has also been critiqued for creating strong differences in mining revenue transfers to regional and local governments of producing areas (as opposed to non-producing areas). The law limits the hiring of foreign nationals to a maximum of 20% and total payroll payments to foreign employees to a maximum of 30% and Peru's tax system includes provisions for granting income tax credits so companies can recover spending on a wider range of public use infrastructure.[7]

In attempts to improve fiscal responsibility and reduce corruption, the central government has imposed strong fiduciary requirements for spending and strict administrative controls through the National Public Investment System (now Invierte Perú).[11] Peru was the first country in Latin America to adopt standards related to tax revenues produced by the Extractive Industries Transparency Initiative (EITI).[12] As a result, it has shown considerable progress in bringing transparency to payments from mining companies and determining the extent to which those payments flow back into the development of mining areas.[11]

Low- and middle- income countries engaged in mining have seen higher foreign direct investment, export revenues and fiscal revenues. For example, World Gold Council (WGC) member companies paid US$7.6bn in tax payments in 2020 to governments in 38 countries.[13] Higher state revenues by themselves do not necessarily translate into increased prosperity, but when combined with improved infrastructure and close integration to other industries, especially via domestic procurement, evidence suggests there was a correlation with higher employment rates.[7] These countries have outperformed their income peers on health and education indicators (in the period from 2000 to 2010), suggesting that at least some of the benefits from mining were being shared and contributing to improved access to quality health and education services.

It is difficult to accurately assess the scale of employment provided by the mining sector due to a lack of data. However it is estimated that the direct contribution of mining to the total formal employment of a country is typically 1-4% in countries with large mining sectors.3 In 2021 in the United States, the mining industry provided 1.2 million jobs.[14]

Countries with reserves of transition minerals are seeing a rapid growth in mining-related employment. In Chile, there was a 38% growth in employment in direct mining operations between 2020-2023.[15] In 2020, WGC member companies directly paid US$8.7bn in employee wages in 38 host countries, with 95% of the workforce comprising local employees. Every job within a WGC member mining operation is estimated to support six further jobs, and up to ten jobs if induced jobs (i.e. employment created by each employed person's additional spending) are included in this figure.[13]

Mining's contribution at local level is contested by some parties but is clearly substantial, especially through local procurement generating local employment and skills development.[16,7] In many cases, procurement by a mining operation can be the single largest potential economic impact in a host country.[17] This has contributed to Chile moving from a scenario in which most goods and services required by the mining sector were imported, to the country becoming a prominent supplier to the region, reported by the World Bank (2012) to be responsible for employing around 10% of the Chilean workforce.[7] According to the WGC, its member companies paid US$26.2bn via in-country procurement globally, with a resulting indirect value-add estimated at US$21.6bn to local suppliers.[13] The Mining Association of Canada (MAC) found that eight MAC member companies spent 91% of their total expenditures in the host country.[18]

Infrastructure, such as roads, airstrips, water supplies, sanitation systems and electricity represents another important contribution. Where there is advance planning and coordination and a willingness to consult with the community, the infrastructure required by mining can be used by other industries and the local population, bringing lasting benefits at limited or no extra cost.[16] The Bolivia Mining Code, permits companies to invest in community infrastructure and to offset this against tax liabilities.[16] In Canada, the mining sector has also contributed to national infrastructure. Each year it is estimated that the industry accounts for 50% of all rail freight revenue within the country.[19] Infrastructure can be especially beneficial when mines are developed in previously hard-to-access areas. They can bring roads, health clinics, education and new livelihood opportunities to previously impoverished areas.[16]

## 2.2. Environmental Impacts

**Key Takeaways**

- The mining sector can have a wide range of environmental impacts, most importantly, land use change, pollution and water exploitation.
- Mining is a substantial contributor to deforestation, both directly and through associated road and rail infrastructure, and is increasingly impacting areas of biodiversity importance.
- Water, air and soil pollution can be managed, but where they are not well managed, they can be a key source of community opposition to mining given their impacts on health, livelihoods and the environment.
- Mining can be water intensive and transition minerals in particular are often located in arid or water-stressed areas. Increasing drought caused by climate change will make competition for water fiercer. Mines can work to recycle and reuse water to reduce their impacts on water.

Environmental degradation is one of the key criticisms levelled at the mining sector. Most industries in the modern economy adversely affect the environment in one form or another. In the case of mining, the three most critical drivers of environmental impact are land use change, pollution and water use. These drivers can degrade the environment directly, indirectly, or via induced impacts (see Box 5) – and can cause impacts at site, landscape, regional and global scales, which can be cumulative over time. This section summarises the environmental impacts of the mining sector by each of these drivers.

It is also important to note that mining companies are stewards of large areas of land (as well as freshwater and marine areas), with the potential to make positive contributions to nature restoration both within active leases and following mine closure. However, there is currently limited publicly available information on the aggregated impacts of nature restoration efforts. Instead there is mainly individual site-based examples reported by some companies.

## Box 5. Direct, Indirect and Cumulative Impacts of Mining Operations

The Task Force on Nature-related Financial Disclosure (TNFD) defines impacts as "changes in the state of nature, which may result in changes (positive or negative) to the capacity of nature to provide social and economic functions." Impacts can be:

- Direct, as a change in the state of nature caused specifically by business activities with a direct causal link;
- Indirect, as a change in the state of nature caused by business activities with an indirect causal link. Indirect impacts are sometimes referred to as induced impacts.

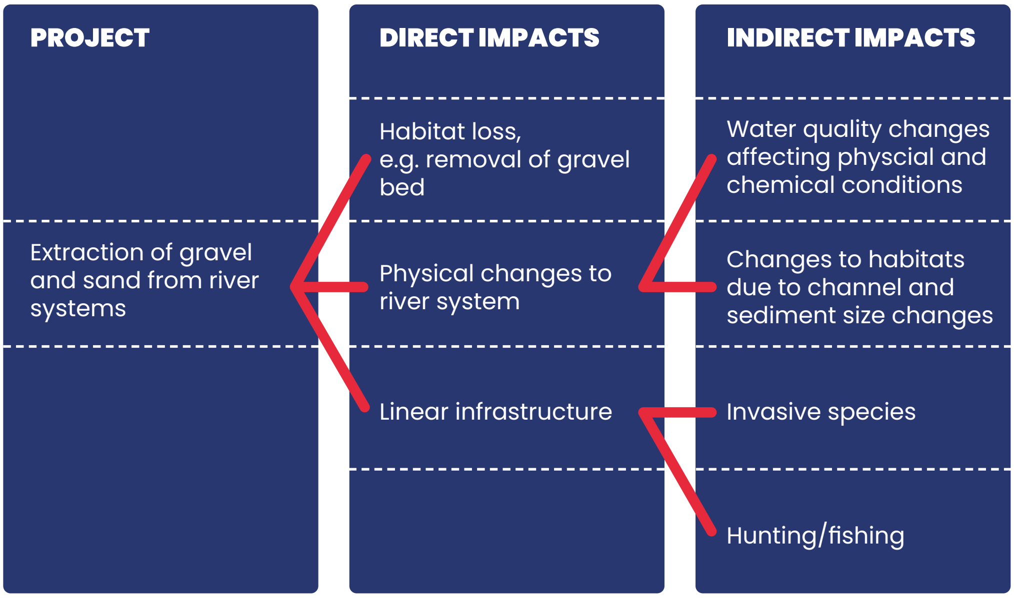



*Figure 2.2. Schematic Illustrating Direct and Indirect Impacts. Adapted from Koehnken et al (2020).*[20]

Impacts can also be cumulative, arising from the combined impacts of mining operations, those of other organisations, and other background pressures and trends (Figure 2.3). This can be an aggregation of both direct and indirect impacts. Cumulative impacts can be greater where you have a concentration of different mines in the same area and where this is not considered in mine planning, operations or closure.

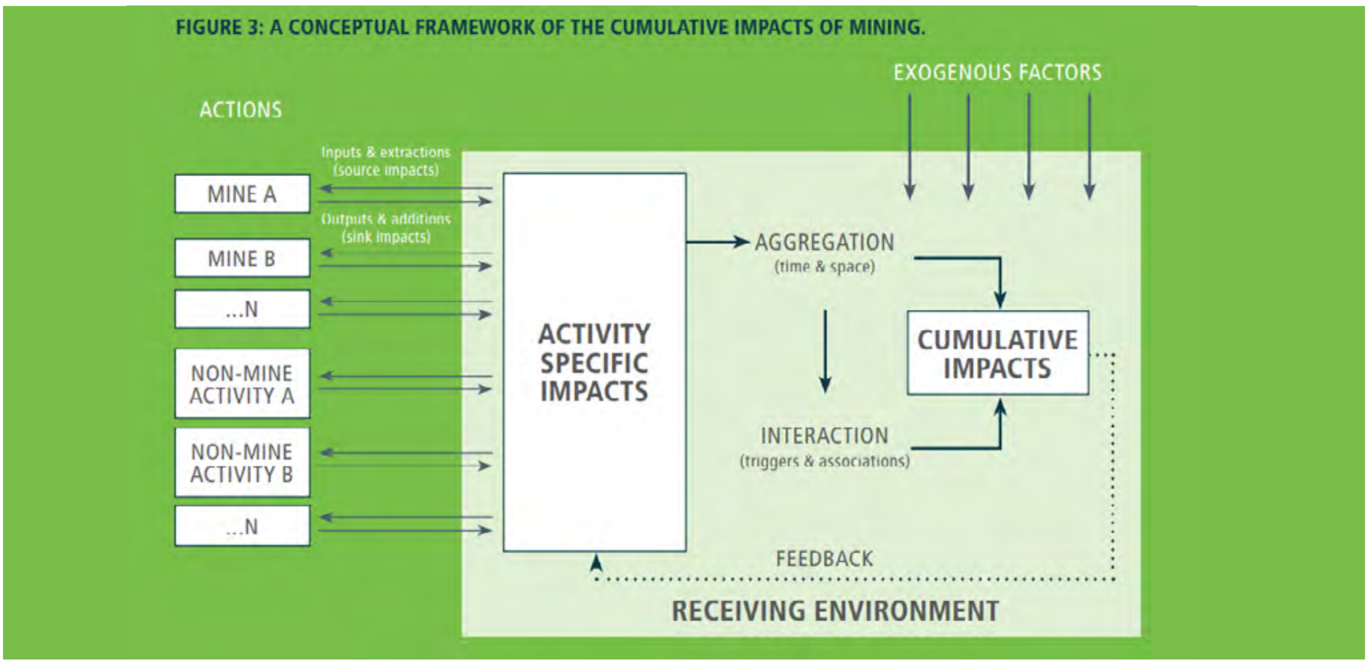



*Figure 2.3. Conceptual Framework of the Cumulative Impacts of Mining. Source: Franks et al (2010).*[21]

## Case Study 7: Environmental Impacts of Mining in Indonesia

Indonesia has the second highest rates of deforestation globally.[22] A recent study of direct deforestation caused by large-scale mining operations across 26 countries found that Indonesia was responsible for 58% of the tropical forest lost to the direct impact of mining (1,901km2) between 2000 and 2019.[23] Further, 5,000km2 of forests in Indonesia lie within nickel concessions, many of which are 'High Carbon Stock'.[24,25]

In 2020, Indonesia's methane emissions from coal mining amounted to 2.8 million metric tonnes of carbon dioxide equivalent, with this number projected to reach 2.9 million in 2035 and 3 million in 2050.[26] Further, as nickel smelting in Indonesia is largely coal-powered, concerns have been raised around the impacts of mineral refining on local air quality and health. Almost 80% of all emissions from the provinces of Central Sulawesi, Southeast Sulawesi, and North Maluku are from nickel smelting and processing activities.[27] With air pollution linked to a higher prevalence of asthma, chronic obstructive pulmonary disease, strokes, diabetes, lower respiratory tract infections and premature births, the Centre for Research on Energy and Clean Air suggests that, without meaningful interventions to mitigate against emissions, the Indonesian nickel industry could result in 5,000 deaths in 2030.[27]

Mining and refining in Indonesia has been linked to water pollution. Communities in Central Sulawesi and Halmahera have claimed that nickel operations have led to the degradation of freshwater sources and harmed the fisheries industry on which many coastal villages depend.[24] Coal mines in South Kalimantan have been documented as illegally discharging toxic pollutants into streams and rivers.[28] More recently, concentrations of aluminium, iron and manganese have been found in freshwater sources surrounding Indonesian coal mines, and are suggested to have impacted washing, crop production and fish farming.[29] As coal operations are highly water intensive, concerns have also been raised around the overuse of fresh water resources in Indonesia. One study suggests that almost half of all rivers in South Kalimantan are at risk from coal mining activities.[30]

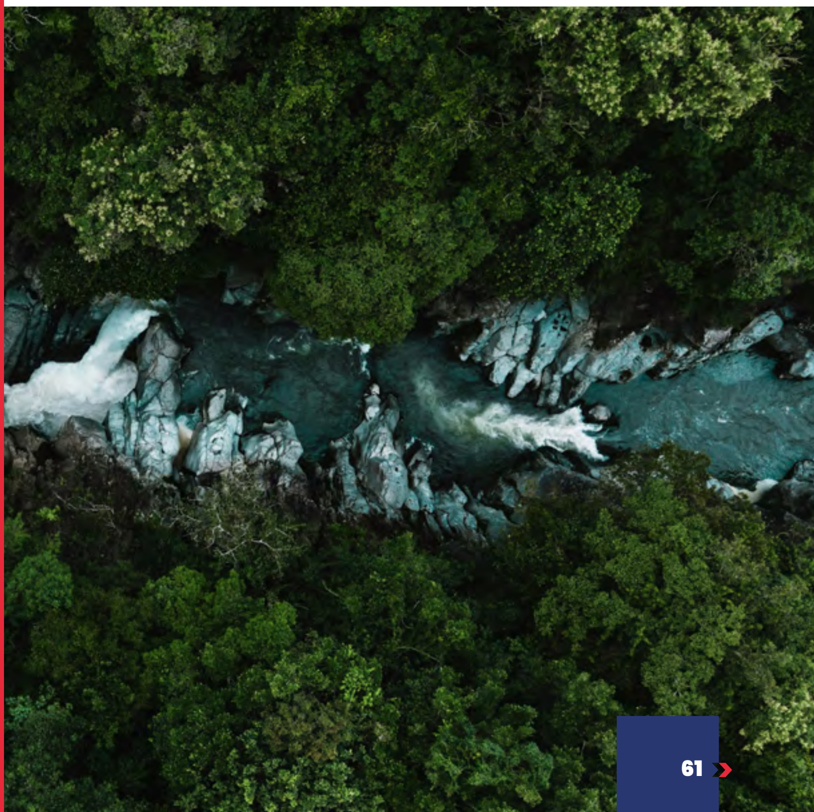
Nickel mining in Indonesia has been associated with Deep Sea Tailings Disposal (DSTD). For instance, in 2019, the local government of the Obi Islands approved a DSTD plan for the company Trimegah Bangun Persada (Harita Nickel).[31] However, following pressure from downstream industries, particularly EV manufacturers, the Indonesian government has stopped granting permits for DSTD.[32]

## 2.2.1. Land (and Sea) Use Change

Mining is only directly responsible for <1% of total global land-related biodiversity impacts overall.[33] However, these impacts can be substantial locally.[34] In terms of the direct impacts of mining through extraction and associated infrastructure on site, the two biggest concerns are land use change and operations in areas of particular biodiversity importance.

Mining is the fourth largest direct driver of deforestation, after agriculture, infrastructure and urban expansion.[35] Direct deforestation as a result of mining operations was estimated to be >13,500km² between 2001-2020, which is relatively small in the context of 100,000km² of deforestation annually.[36] Within this, coal and gold mining are considered the largest contributors, accounting for 71% of direct mining-related deforestation. More than a third of this forest loss has taken place over the last five years.[37] Based on a paper released by the World Wildlife Fund (WWF), 84% of this direct mining-related deforestation occurred in just ten countries (Indonesia, Brazil, Russia, Canada, United States, Australia, Peru, Myanmar, Suriname and Ghana).[37] This estimate of deforestation does not account for any reforestation that may have taken place in these (or other) locations.

Mining also has indirect and induced impacts on land use. While the road and rail infrastructure delivered by mines can bring numerous social and economic benefits, it can also lead to induced negative impacts such as land conversion and over-exploitation of natural resources by an increased population.[38,39] It is estimated that mines potentially have a zone of influence, including potential negative ecosystem impacts, that can extend 50-70km from the mine site itself. [40,41,38,39]



Deforestation around the Grasberg gold and copper mine in Papua, Indonesia is estimated to be >42 times more extensive than the mine site itself.[33,42] A study in the Brazilian Amazon found that mining contributed to deforestation up to 70km beyond mining lease boundaries, causing 11,670 $km^2$ of deforestation between 2005-2015.[40] This represents 9% of all Amazon forest loss in this period and 12 times more deforestation than occurred within mining sites alone.[40] The potential pathways leading to this deforestation were identified as "infrastructure establishment, urban expansion to support a growing workforce, and development of mineral commodity supply chains."

Drawing on this, a report by the WWF estimated that, when accounting for the indirect impacts of mining activities (e.g. mining related infrastructure, settlements, agriculture through settlement, water and soil contamination), mining may be impacting around a third of the world's forest ecosystems.[37] However, indirect mining-related deforestation is rarely documented, and it can be challenging to link it back to mining.

Moreover, mining is increasingly impacting areas of biodiversity importance, including a doubling in extraction volumes from tropical moist forest ecosystems.[43] According to an S&P Global analysis in collaboration with UNEP, of 1,276 mining sites that overlap with Key Biodiversity Areas  (representing approximately 10% of the total), 29% are for extracting transition minerals, and most of these (67%) are only in the exploration stage.[44]

A World Bank study (2019) found that 1,539 large-scale mines[ii] (or 44% of operational mines) are operating in forests.[45,iii] In addition, a further 1,826 forest-based sites were in development or currently non-operational at the time of analysis, mostly open-pit mines.[45] According to the research, mining within forests accounts for >50% of all mining in North America and South Asia, and is most common in countries with the largest land areas (China, Russia, Brazil, Canada, and the United States). When "accounting for area, economic importance and forest cover", however, Brazil and the DRC were the most important for forest mining.[45] Minerals most mined in the largest volumes from forest were gold, iron ore and copper, but the minerals most reliant on mines located within forests were bauxite, nickel and titanium (Table 2.1). At the time of the analysis, mining companies with the highest percentage of large-scale mines in forested areas were Vale (92% of its portfolio or 6% of all forest mines), Rusal (>80% of portfolio), and Dragon Mining (>80% of portfolio).

| | Commodity | % total global production value | Total mines | Total MFAs | % all MFAs | % mines in forests |
|---|---|---|---|---|---|---|
| 1 | Iron | 11 | 506 | 246 | 16 | 49 |
| 2 | Gold | 9 | 1,010 | 473 | 31 | 47 |
| 3 | Copper | 9 | 399 | 157 | 10 | 39 |
| 4 | Maganese | 8 | 106 | 52 | 3 | 49 |
| 5 | Chromite | 5 | 98 | 30 | 2 | 31 |
| 6 | Nickel | 3 | 146 | 88 | 6 | 60 |
| 7 | Zinc | 2 | 187 | 83 | 5 | 44 |
| 8 | Titanium | 2 | 30 | 19 | 1 | 63 |
| 9 | Bauxite | 1 | 122 | 78 | 5 | 64 |
| 10 | Silver | 1 | 113 | 31 | 2 | 27 |

*Table 2.1. Mining in Forests for the Top 10 Commodities by Production Value. Data Source: Maddox et al (2019).[45]*

i Sites qualify as global key biodiversity areas (KBAs) if they meet one or more of 11 criteria, clustered into five higher level categories: threatened biodiversity, geographically restricted biodiversity, ecological integrity, biological processes, and irreplaceability. The Global Standard for the Identification of Key Biodiversity Areas (IUCN 2016) sets out globally agreed criteria for the identification of KBAs worldwide: https://portals.iucn.org/library/node/46259

ii Large Scale Mining (LSM) refers to capital-intensive, legal mineral extraction usually performed by companies or associations, often divided into three categories according to size: majors, mid-tier, and juniors.

iii As per the FAO definition of forest: https://www.fao.org/3/ad665e/ad665e06.htm

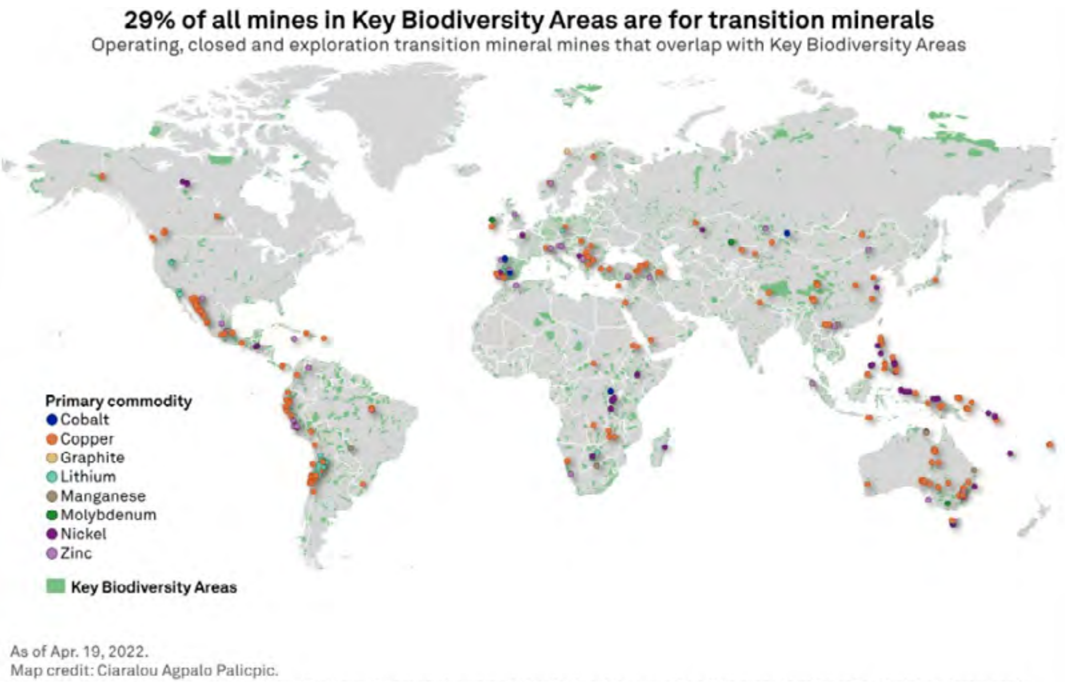



*Figure 2.4. Mine Sites that Overlap with Key Biodiversity Areas (KBAs). Source: Whieldon et al (2022).[44]*

Whilst forest ecosystems have been subject to the most research in relation to mining impacts, mining operations are also directly and indirectly causing degradation in a wide range of other terrestrial biomes. These include arctic tundra,[46] grasslands,[47] alpine deserts,[48] freshwater,[49] coastal and marine[50] ecosystems. Mining in the deep seabed (at depths of >200m which represents around two-thirds of the ocean floor)[51] is increasingly being evaluated. There are measurable reserves of key minerals, including copper, cobalt, nickel, zinc, silver, gold and REEs, occurring on the seabed as polymetallic nodules and polymetallic sulphides (Figure 2.5).[52]

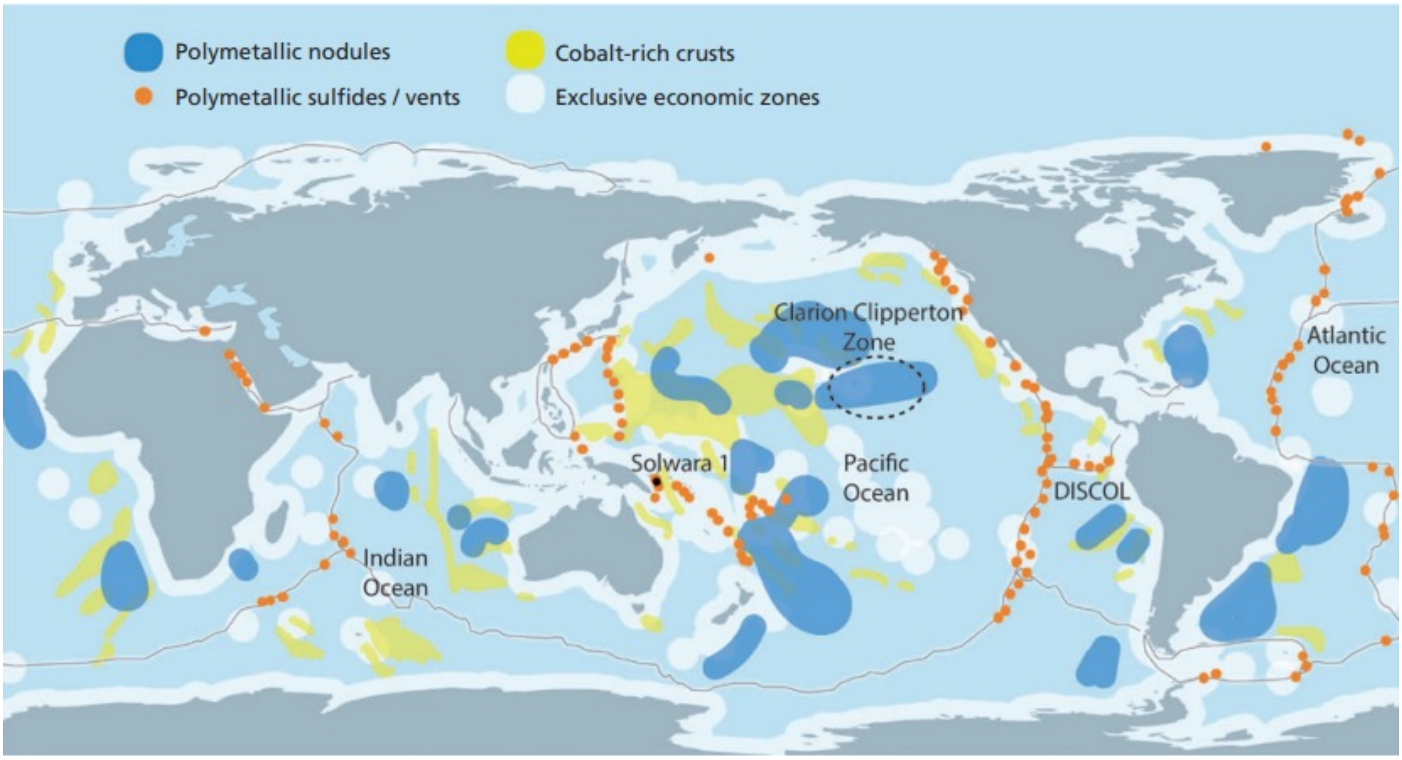



*Figure 2.5. Location of the Three Main Marine Mineral Deposits: Polymetallic Nodules (blue); Polymetallic or Seafloor Massive Sulfides (orange); and Cobalt-rich Ferromanganese Crusts (yellow). Source: European Academies' Science Advisory Council (2023).[52]*

### Box 6: Deep Sea Mining

The deep sea is relatively poorly understood, making it challenging to assess the environmental impacts of mining operations and design effective safeguards to avoid reducing these impacts. Based on current understanding, there are concerns around the environmental damage deep sea mining could cause. Potential impacts vary by extraction method and can be summarised as:[51]

- Alteration or destruction of habitats resulting in potentially irreversible loss of species and ecosystem function.
- Disturbance of sediment, creating sediment plumes which may smother marine life and detrimentally impact marine life by interfering with visual communication.
- Noise, vibration and light pollution from mining activities, and release of pollutants as a result of leaks or spillages resulting from mining processes, with negative impacts on marine life and ecosystem function.

A review of available evidence by the European Academies Science Advisory Council (2023, p17) highlights gaps in knowledge about the deep-sea ecosystem but concludes "it is clear that mining will have the following effects: biota in areas directly mined will be killed; the remaining sediment discarded on site is likely to be inhospitable to recover" for decades (for seafloor massive sulphide bodies) and decades to centuries (in the case of nodules and cobalt-rich crusts). The loss in hard substrates and the structure of habitats may lead to indefinite reductions in biodiversity loss."[52]

Deep sea mining has a large potential footprint. For example a single manganese mining operation would be projected to impact 300–700km$^2$ annually[53] and 17 deep-sea mining contractors have already received exploration contracts with a combined exploration area covering approximately 1,000,000km$^2$ (or 3.8% of the deep seabed).[54] As a result of the potential for sediment plumes and disruption of processes related to $CO_2$ and methane emissions, one study has estimated that a single manganese mine operation impacting 300-700km$^2$ a year directly could affect an area two to five times greater as a result of transport of sediment, potentially increasing to >50,000km$^2$ over 15 years.[53]

In turn, this could have wider impacts on fisheries, seafood contamination, carbon transport and terrestrial biodiversity,[51,55] with widespread social and economic implications for economies who rely heavily on fisheries and marine life.[56] Moreover, studies in areas where mining exploration is currently being undertaken[57] demonstrate high levels of biodiversity.[58] Nodules can take millions of years to develop,[52] and the areas potentially impacted include some of the oldest organisms on the planet, such as corals over 4,000 years old[59] and sponges up to 11,000 years old.[60]

As a result of these concerns, 32 countries[61] and the EU Parliament[62] have called for a moratorium on deep sea mining until the environmental impacts are better understood.

On the other hand, proponents of deep sea mining argue that it can help to meet the demand for transition minerals, avoid many of the land-based environmental and social impacts,[63] and may reduce the carbon footprint of batteries.[i]

Due to its inaccessibility, it also has the potential to avoid social issues linked to in-migration and the labour rights issues associated with increased ASM activity around land-based mining operations.

By May 2022, the International Seabed Authority had issued around 31 contracts to explore deep-sea deposits in an area of around 1.5 million km$^2$.[51] Currently, Papua New Guinea is the only country that has issued an exploitation licence.[64]

i Benchmark Mineral Intelligence. (2023). The Metals Company—life cycle assessment for TMC's NORI-D polymetallic nodule project and comparison to key land-based routes for producing nickel, cobalt and copper. Available at: https://metals.co/wp-content/uploads/2023/03/TMC_NORI-D_LCA_Final_Report_March2023.pdf

## 2.2.2. Pollution

Mining can be a source of water, earth and air pollution. This can occur through acid rock drainage, heavy metals leached from waste storage, from concentrates at the mine site, the leaking of mercury or cyanide, and dust emissions. To an extent, these impacts can be, and often are, prevented or mitigated. However, where they are not, they can have a serious effect on the environment and on the lives and livelihoods of communities.[65]
This can affect the health of people and their livestock, reduce harvests and fisheries catch and, in certain areas, impact tourism revenues.

### Water Pollution

Where it happens, pollution of local surface and groundwater water sources at mine sites occurs in four main ways:

1) Mining of certain minerals (e.g. gold) can result in Acid Rock Drainage. This is when water and oxygen react with sulphide minerals in mined or otherwise exposed rock, leading to acidic water that can catalyse the release of further toxins (e.g. arsenic, lead), which then drain into surrounding water courses and aquafers.
2) Mining operations can cause disturbance and erosion that can transport sediment into water, reducing water quality and altering its chemistry.
3) The chemicals used in extraction and processing (e.g. mercury and cyanide used to process gold) can cause water contamination. This is a particular problem associated with ASM and historic mine sites, but also occurs in industrial mining.
4) Aqueous tailings disposal whereby tailings are deposited directly into oceans, rivers or streams.

Water pollution can happen by accident, through neglect, or even as the result of deliberate policy and can occur in both lightly and tightly regulated jurisdictions. For example:

- A review of copper mines generating 90% of US copper found that all reported at least one (and most multiple) accidental failures, resulting in a range of environmental impacts including contamination of drinking water and wildlife loss.[66]
- In Canada, water pollution through acid rock drainage, metal leaching, salt accumulation and wastewater treatment has resulted in impacts on water quality, aquatic biodiversity and human health in mining areas.[67,68]
- In Australia, a nickel refinery recently disposed tailings-contaminated wastewater illegally into the Great Barrier Reef World Heritage area.[69]
- An Alaskan mine has earned the title of most "toxics-releasing" facility in the American EPA Toxics Release Inventory as a result of lead and cadmium in treated mine wastewater entering downstream watercourses.[70]
- In Indonesia, nickel mining operations have caused river pollution,[71] damaged lagoon ecosystems,[72] generated conflict with biodiversity-related tourism[73] and is threatening marine life in Southeast Asia.[74]

### Air Pollution

Air emissions are produced by mining activities and without active management, can lead to air pollution. These can include sulphur oxides (SOx), nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOCs), ammonia (NH3), carbon monoxide (CO), carbon dioxide (CO2), methane (CH4), and fine particulate matter (PM2.5, PM10), potentially impacting the environment and human health.[75]

Examples of air pollution resulting in environmental and health impacts in large-scale mining operations include:

- The smelting and refining of copper can release sulphur dioxide which creates acid rain damaging local vegetation (including crops) and even buildings.[76]
- Arsenic in dust and aerosol generated by certain mining activities can be "definitively linked to increased systemic uptake, as well as carcinogenic and non-carcinogenic health outcomes."[77]
- Bauxite mining releases fine dust particles which can lead to respiratory and cardiovascular health problems.[78]
- Graphite mining can cause a respiratory condition called graphite pneumoconiosis, resulting from inhaling graphite dust, which can affect both workers and those living close to graphite mines.[79]
- Copper miners' exposure to silica can cause pulmonary tuberculosis.[80]
- Open-cut mining of laterites in nickel mines can release large amounts of dust that can cause respiratory illnesses and cancer.[72]
- Coal mining, especially surface mining, can contribute to local air pollution,[81–83] which can generate genotoxic impacts[82] and elevated risks of cancer and cardiovascular and respiratory diseases amongst local communities.[84–87]

A research brief by the UK Parliament[88] estimated, based on 2016 data, that industrial mining and ore processing exposed 7 million people globally to air pollution from heavy metals, resulting in 0.45-2.6 million Disability Adjusted Life Years (DALYs). While gold-related ASM exposed 4.2 million people (and cost 0.6-1.6 DALYs). In the EU in 2021, the manufacturing and extractive industries were responsible for 63% of lead, 55% of cadmium, 44% of mercury, and 36% of arsenic emissions, and were the main sources of NMVOC emissions.[89]

### Soil Pollution

Soil pollution from mining, where not adequately managed, usually occurs via water (e.g. dissolved pollutants) and air (e.g. settling of dust). Key contaminants of soil are arsenic, cadmium, chromium, copper, mercury, nickel, lead, tin, titanium and zinc.[90] At certain levels of contamination, this can impact plant growth, and in turn ecosystem and human health through reduction in crop yields or crops that are unsafe for consumption.[91]
For example:

- In the Boké region of Guinea, pollutants from large-scale industrial bauxite mining reduced soil fertility. This contributed to increased food insecurity and respiratory problems amongst local people.[92,93]
- In Katanga province in DRC, where ASM cobalt mining of cobalt is prevalent, toxic concentrations of cobalt salts are present in the soil[94,95] and higher levels of cobalt were found in the urine and blood of local people (compared to a nearby control area). Children in the area were also found to have evidence of exposure-related oxidative DNA damage.[96]

## Case Study 8. Pollution from China's Domestic Mining and Processing Activities

As a substantial amount of mining and refining takes place in China (which has predominantly coal-based electricity), the country's GHG emissions are very high.[97,98] Burning coal is considered the single largest source of air pollution in China and estimated to have caused 366,000 premature deaths in 2013.[99]

The mining of REEs in China is associated with pollution resulting from the use of chemicals in the separation process. [100, 101] The largest REE mine in China (and the world) - Bayan Obo - has produced a tailing pond with over 70,000 tonnes of radioactive thorium.101 The contents of the tailing pond have been seeping into the groundwater and will eventually hit the Yellow River, which is a key source of drinking water for millions of people in the North of China.101 'Cancer villages' have been acknowledged by the Chinese government; a term used to describe areas where a disproportionately large number of people have fallen ill due to mining-based pollution.[102, 103]

This has resulted in civil unrest. In 2011, communities of the Lhamo mountains urged the government to take action after being affected by water pollution from lead mining in the Ganhetan Industrial District.104 In one letter posted on a blog, an anonymous individual reported how the communities around the industrial park suffered pollution by toxic gases and dust.104 Another letter reported that more than 100 children had excessive levels of lead in their blood from the polluted water.[104] In 2015, hundreds of individuals took to the streets in Guangdong Province protesting the expansion of a coal-fired plant. Since the plant in Heyun city began operations in 2008, residents had complained of smog and pollution, yet the government approved plans for a second phase of the project.[105]

### Solid Waste and Tailings

Mining creates substantial volumes of solid waste and tailings.[106] For example, mining and quarrying generated 21% of total hazardous waste and 21% of total waste in Europe in 2020.107 It is predicted that fulfilling demand for transition minerals could generate up to 13 billion tonnes of additional waste rock annually.[108]

The management and storage of tailings require long-term, active monitoring. Almost a tenth of mining storage facilities are located within Protected Areas (with half established after the Protected Area was designated). A further 20% of facilities are within 5km of one, placing areas of high biodiversity value at risk.[109] On average, there are at least five major tailings dam failures annually, and since 1960 at least 2,375 people have lost their lives in tailings disasters.[88]

The physical failure of tailings storage can engulf the surrounding area, damage the environment and infrastructure, and cause fatalities. This happened, for example, at Mount Polley gold and copper mine in Canada in 2014, the Fundão dam at Samarco mine, and at Brumadinho in Brazil in 2015 and 2019 respectively.[110] The collapse of the latter tailings storage facility led to mining waste inundating the surrounding areas, killing 270 people. The collapse of the Fundão dam released 43 million cubic metres of iron ore tailings, polluting 668km of watercourses all the way to the Atlantic Ocean.[111] Moreover, impacts associated with tailings (physical land footprint used, the potential for pollution of air, water and soil, water use) are predicted to be exacerbated by more frequent and severe weather events caused by climate change.[112]

Alongside these impacts and risks, there are untapped opportunities to create value through re-use and re-purposing of commodities found in tailings waste. This has the potential to open up new revenue streams whilst also reducing environmental impacts and creating employment opportunities for local communities.

## 2.2.3. Climate Change

Mining makes a limited direct contribution to GHG emissions. It is estimated to currently account for 4-7% of GHG emissions globally, with mining operations (Scope 1) and power consumption (Scope 2) amounting to 1% of this (i.e. 0.04-0.07% of global GHG emissions). Fugitive-methane emissions released during coal mining account for the remainder (Figure 2.6).[113] If Scope 3 is considered, mining would be responsible for a much more significant share of global emissions (28%), mainly through coal-based power to produce energy (20%, excluding power for mining and metals) and for industry (8%, primarily steel and aluminium production).[97,113]

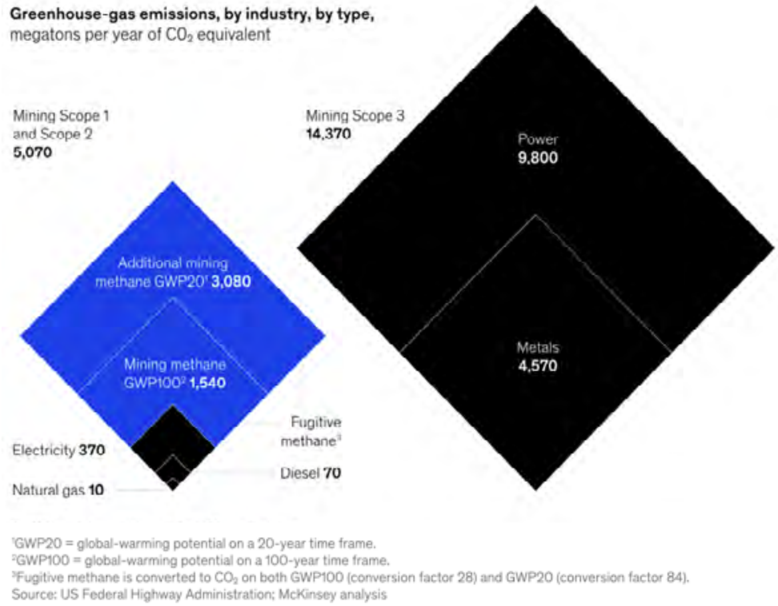



*Figure 2.6. Mining-related GHG Emissions by Industry, by Type. Source: Delevingne et al (2020).[113]*

Amongst non-ferrous minerals aluminium has the largest carbon footprint (with smelting the most energy intensive process), due to its high annual production volume and averaging at 18t CO2/t produced, including mining (extraction and enrichment) and production (smelting and/or refining).[97] Aluminium production can be largely electrified, but an estimated 60% of global primary production takes place in China and is mostly coal powered.[97] Steel manufacturing requires coal for both heating and metallurgical processing, with coal-reliant blast furnacing being used in 90% of current steel production from iron ore and 71% of steel recycling. This accounts for 12% of global coal use annually.[97]

Intensity of emissions varies notably across companies and regions. A substantial amount of mining and refining takes place in China (which has primarily coal-based electricity), the country's carbon footprint is very high.[97] Silicon production including mining (extraction and enrichment) and production (smelting and/or refining) has an average footprint of 11t CO2/t, over half of which is due to energy consumption. This footprint has increased over the last two decades due to China's growing market share in production and its reliance on coal-based power generation.[97]

### 2.2.3 Water Exploitation

Mining is water intensive. This makes it vulnerable to drought and magnifies the environmental impacts in areas of existing water scarcity. For every tonne of mined lithium, 170 cubic meters of water is used,[114] while lithium extraction via evaporation processes can require even more water (an estimated 469 cubic meters of water per tonne).[114] High level of water use for mineral extraction can alter local hydrology and water availability resulting in changes in habitat and species composition.[115,116]

Water use varies by mineral, and process. In the selection of minerals shown in Figure 2.7, water consumption ranges from 10 - 200m³ per tonne of metal (or Lithium Carbonate Equivalent in case of lithium) according to one model (Argonne GREET).[97] WWF's Risk Filter highlights coal, bauxite, iron, gold, copper, lithium, and titanium as being of high overall water risk,[117] i.e. produced in areas facing high overall water risk calculated using WWF's water risk methodology combining physical, regulatory and reputational risks.

| Commodity | Process water consumption | Energy water consumption | Commodity |
|---|---|---|---|
| Aluminium | 10 | 228 | Primary Aluminium ingot (Source: Argonne) |
| Copper | No Info | 9.5 | Smelted and refined copper (Source: Argonne) |
| Zinc | 35 | 13 | Ore mining and zinc production (Source: Argonne and Zn LCA (Blue water consumption)) |
| Silicon | No Info | 27 | Metallurgical grade silicon (Source: Argonne) |
| Lithium | 22-45 | 6 | For average lithium carbonate (Source: Argonne) |
| Nickel | 3 | 130 | For final refined nickel (Source: Argonne) |
| Cobalt | 100 | 130 | Virgin cobalt metal product (Source: Argonne) |
| REE | 200 | No Info | Mining and metal production (Source: REE LCA) |

*FFigure 2.7. Average Water Consumption for Metal Production (Mining and Metal-making Steps). Source: Gregoir & Acker (2022), based on Argonne and LCA data.[97]*

Most (>70%) mining operations of the six largest mining companies are located in water-stressed countries.[118] A recent study found that at least 16% of the world's land-based, "critical mineral mines, deposits and districts" are in areas already facing high or extremely high levels of water stress, while a further 8% of "critical mineral locations" are located in arid or low-water areas and are therefore vulnerable to water stress should mining activity increase in these areas.[119] WWF's Water Risk Filter identifies mining areas with high overall water risk as Australia, China, Chile, India, Peru, South Africa and the US.[117]

Close to 40% of copper is produced in countries with moderate water availability (especially Chile)97 and 33% of copper reserves are in high water-risk countries.[120] For example, in Salar de Atacama in Chile, lithium and copper mining is reported to have consumed more than 65% of the local water supply, depleting the water available to Indigenous farming communities in an already water scarce area.[119] Around 75% of lithium production is located in countries with moderate water scarcity risk, such as Chile and Australia. Figure 2.8 combines WWF Water Risk Filter data on water scarcity risk with mine output (% share of total mine output by commodity), highlighting the countries and minerals where water scarcity is highest. This includes bauxite and lithium in Australia, copper and lithium in Chile, zinc, silicon and REEs in China.[97]

This high dependence on water and overlay with areas of water stress is, amongst some companies, catalysing innovation to reduce dependence on local water resources. For example, through use of rain harvesting and water recycling. Wider application of these approaches and technologies can help to reduce reliance of mining operations on local water sources.

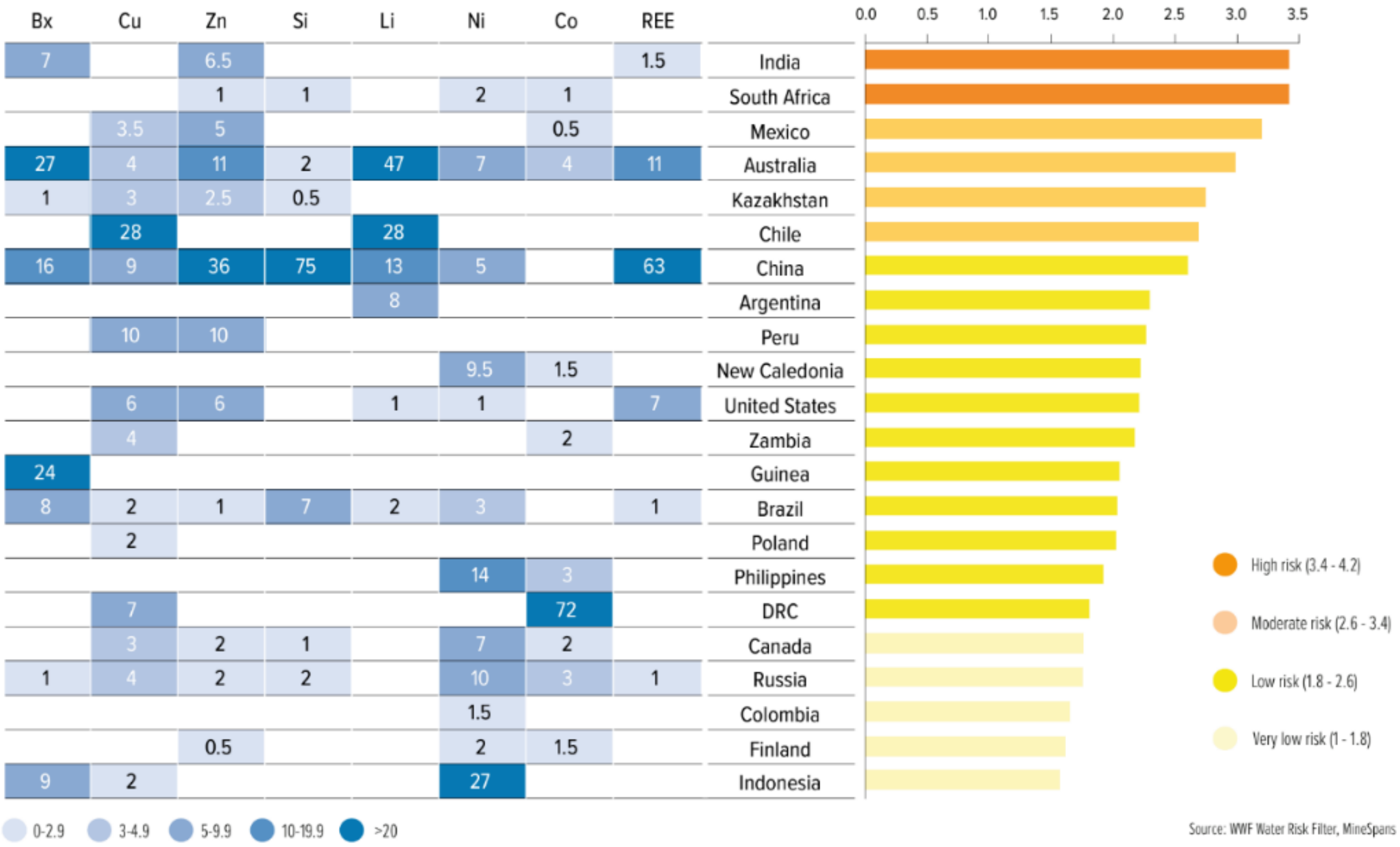



*Figure 2.8. Mineral and Country level Water Scarcity Risk. Source: Gregoir & Acker (2022).[97]*

## Case study 9: Mining Contributes to Water Scarcity in Chile

Much of Chile's mining industry is concentrated in the water-scarce regions of Antofagasta and Atacama.[121] This leads to greater competition for groundwater and surface water sources.[122] For example, the Andina copper mine of Codelco in Los Andes Province has been exacerbating water shortages and contributing to glacier retreat, meaning villages around the Andina mine must be supplied by water tanks as water sources have dried up or become contaminated.[123]

Chile has largely tried to combat this issue through desalination projects. An estimated 70% of the desalination plants supply water to the mining sector.[124] The National Mining Policy 2050 requires new large-scale mining projects to, "Decrease the percentage of continental water use, not exceeding 10% of total water used by 2025 and 5% by 2040, promoting other sources that do not compete with human consumption."[125]

These desalination projects are associated with other environmental impacts however including the alteration of salt concentrations in coastal waters and disruption of spawning habitats.[124] As a result, fishermen from indigenous and traditional coastal communities have protested against desalination development due to the impacts on fish stocks and fisheries.[126]

Competition over water resources can be a key source of conflict between mining companies and local communities.[127] Mining companies are increasingly sourcing water from desalination projects. Some companies are not always willing to share their desalinated water supply with their neighbouring communities due to the high costs involved.[128]

Several mining projects have been delayed or suspended as a result of local opposition,[129] including in relation to concerns over the depletion of water resources.[127] In 2019, a plan to expand a lithium mine in the Atacama Desert was suspended over complaints raised by Indigenous communities about the mine's potential impact on water supply.[130] As a result of these social and environmental issues, especially around water scarcity, around US$12billon of investments made by large-scale mining companies (equivalent to 80% of investments submitted to Chile's Environmental Authority) were contested by civil society between 1998 and 2022, with 1 in 5 (21%) currently held up in the justice system.[131]

## 2.3. Social Impacts

**Key Takeaways**

- Human rights impacts are complex because they reach beyond a mine's immediate operations and are not always within a company's control. Mining's strategic and economic importance makes it a source of competition and conflict.
- Mining can present many opportunities for development, but there are also human rights related risks related to resettlement and/or loss of access to land, resources and cultural connections. Mining is particularly exposed to risks around Indigenous rights.
- Labour rights remain a critical issue for the sector. The most significant are occupational health and safety, working conditions and pay, non-discrimination and equal opportunity, collective bargaining and freedom of association and forced labour.
- In-migration associated with mining is a key issue, especially where mining is the main source of economic activity in an area. Many of these impacts can be positive but the adverse impacts can be equally substantial.
- ASM is a major contributor to the minerals supply chain, and a critical source of income in low-income countries. However a lack of regulation can make it dangerous and a target for criminality.

Human rights impacts are amongst the most difficult, contentious and unpredictable challenges for mining companies. These impacts cover almost every aspect of a mine's operations, can encompass those affected by the mine, and extend beyond a company's control. They can involve actors such as contractors and suppliers, communities, governments, state institutions, public security agencies and religious and civil society organisations.

Human rights impacts include the:

- Land: whose is it, what is it being used for, and what significance does it hold.
- Environment: the quality of the air, the water and the soil (see previous section).
- Workforce: conditions, pay, health, safety, collective bargaining and freedom of association.
- Nearby communities: livelihoods, security and well-being. And
- The supply chain.

A mine can impact the rights of many people, in diverse and intricate ways. Collectively, the mining sector has an influence on the lives of millions, particularly when ASM is also considered.

**Box 7: Gender Considerations**

A review by Oxfam (2009) summarised the key ways in which women's rights can be impacted in specific ways by mining activities:[132]

- Women are less likely to be included in consultation processes during mine development. This means they are less likely to be adequately compensated for losses of access to land or resources. Further, compensation directed through male representatives can make women more economically dependent on men or mean those without male representatives are excluded altogether.
- Mining can contribute to transition from subsistence-based economies to cash-based economies, altering women's roles and status, and reinforcing or narrowing women's roles as being in the reproductive and domestic sphere.
- Environmental degradation, or loss of access to land and resources as a result of mining, and men gaining employment in mines, can increase work burdens on women who are responsible for meeting the subsistence needs of their families.
- Increases in a transient male workforce associated with mining activities can also bring issues such as alcoholism, sexual violence, prostitution and disease.

### 2.3.1. Land and Resource Rights

Land and associated resources, are essential to people's livelihoods, determining their access to pasture, food, shelter, culture, work, water, health and well-being. Mining can present many opportunities for development, but there are also well-documented economic, social and environmental risks related to resettlement and/or loss of access to land, resources and cultural connections.[133] People may be displaced from their livelihoods as well from their land, home, community, and social and cultural connections. Where planned or implemented poorly, displacement and loss of rights to land and access to resources can impoverish those affected. Local people's rights to land and resources are increasingly being lost as a result of development, including by mining, especially in the many cases where people lack secure rights over and access to the land and property on which they live and work.[134]

Resettlement can occur at all stages of the mine lifecycle, with a high proportion of resettlement events taking place during the operational phase of a mine.[135,136] Although this is always challenging, mining-induced displacement and resettlement (MIDR) can and does take place voluntarily, with communities engaged throughout the process and receiving fair compensation and improvements in living conditions. However, it is not always handled well, international standards are not always followed, and governments "often invoke the power of eminent domain" resulting in people being relocated.[133,137] Resettlement is considered involuntary when people do not wish to move but do not have the legal right to refuse land acquisition that results in their displacement.[140]

Forced evictions, sometimes violent, damage to cultural heritage sites, insufficient compensation, inadequate benefit sharing, violation of social, economic, and cultural rights, violation of housing rights, and marginalisation and subjugation of vulnerable groups are amongst the impacts associated with poorly-managed MIDR.[138]

### 2.3.2. Indigenous Peoples' Rights

Few groups are more vulnerable or marginalised than Indigenous Peoples (IPs). This is not for lack of international instruments.[iv] Rights officially accorded to IPs include (but are not limited to) the right to self-determination and self-government, their cultures, their lands, territories and resources, and consultation, effective participation in decision-making, and Free, Prior and Informed Consent (FPIC). There is also a rich body of jurisprudence at international, regional and national level substantiating these rights.[v] The jurisprudence of the Inter-American Court on Human Rights, for example has determined that the following measures or conditions must be met prior to the development of large-scale development projects on Indigenous territories:

- Legislative measures to guarantee Indigenous Peoples' right to control their lands, territories and resources, including through demarcation and land titling.
- Prior social and environmental impact assessments.
- Effective consultation with Indigenous Peoples' representative institutions.

**Box 8: Rights of Non-Indigenous Peoples and Local Communities**

Wherever a people or community maintain traditions of collective customary tenure, strong ties to their land, and distinct cultural traditions, collective land and associated rights protections may be applicable".[144] As such, there are other groups, communities or people that have customary rights, such as Tribal Peoples, Afro-Descendant Peoples, local communities, rural, traditional, and peasant communities that do not self-identify as Indigenous and have specific rights or protections, including in some cases to FPIC. These specific rights have been addressed by the land rights standard.[145] The right to self-determination is a right of all peoples; the ILO Convention No.169 and certain rights elaborated on by the Inter-American Court apply to both Indigenous and tribal peoples. Several rights in the African Charter are collective rights of all peoples while the African Commission and Court have both suggested that the right to property includes customary communal tenure rights (not limited to Indigenous Peoples). Local communities are distinct from Indigenous Peoples, and FPIC has been recommended as good practice for all affected local communities.[146]

A study examining FPIC in relation to mining operations by Canadian companies, which at the time were estimated to be involved in 50-70% of mining projects in Latin America found that participation in decision-making and FPIC is rarely implemented.[147] Another found that few mining companies involved in delivering minerals for the energy transition have policy commitments specific to Indigenous Peoples' rights, and those that do "often qualify their commitment to respect FPIC" leaving the option to proceed without consent.[148] This was also a finding by the Responsible Mining Index 2022.[149] Mining projects proceeding without FPIC consequently do not comply with Indigenous Peoples' legal and juridical systems and laws as per the UNDRIP. Recently, the world's second-largest silver mine (Escobal) in Guatemala was closed following the constitutional court ruling that the Xinca Indigenous Peoples had not been adequately consulted before a mine licence was granted.[150]

While many industry standards and multi-stakeholder initiatives exist that have references to Indigenous Peoples' rights, their alignment with international human rights law varies (Box 10). Indigenous representatives have advocated for The International Responsible Mining Assurance (IRMA) to be the minimum standard for mining companies.[143,151]

- Participation in decision-making, including FPIC.
- Just compensation for the deprivation of property, as well as the deprivation of the regular use and enjoyment of traditional lands and resources.
- Reasonable sharing of benefits.

A MapleCroft Verisk analysis, based on 51 different ESG and political risks for 198 countries across 80 industries, shows that the mining sector is especially exposed to Indigenous rights risks.[139] Over 50% of more than 5000 transition mineral projects are located on or near the lands of Indigenous and peasant peoples, the groups whose rights to FPIC are enshrined in international human rights law and most clearly expressed through the UNDRIP (Figure 2.9).[140]

Similarly, IRENA estimates that 54% of energy transition minerals are located on or near Indigenous Peoples' land, the percentage rising to over 80% in the case of lithium projects.[141] In the US, 97% of nickel, 89% of copper, 79% of lithium, and 68% of cobalt reserves lie within 35 miles of Native American reservations.[142] Recognising this intersection, 87 Indigenous representatives recently published (April 2024) a "Declaration of Indigenous Peoples' Participants in the Conference on Indigenous Peoples and the Just Transition" highlighting the importance of Indigenous People spearheading renewable energy

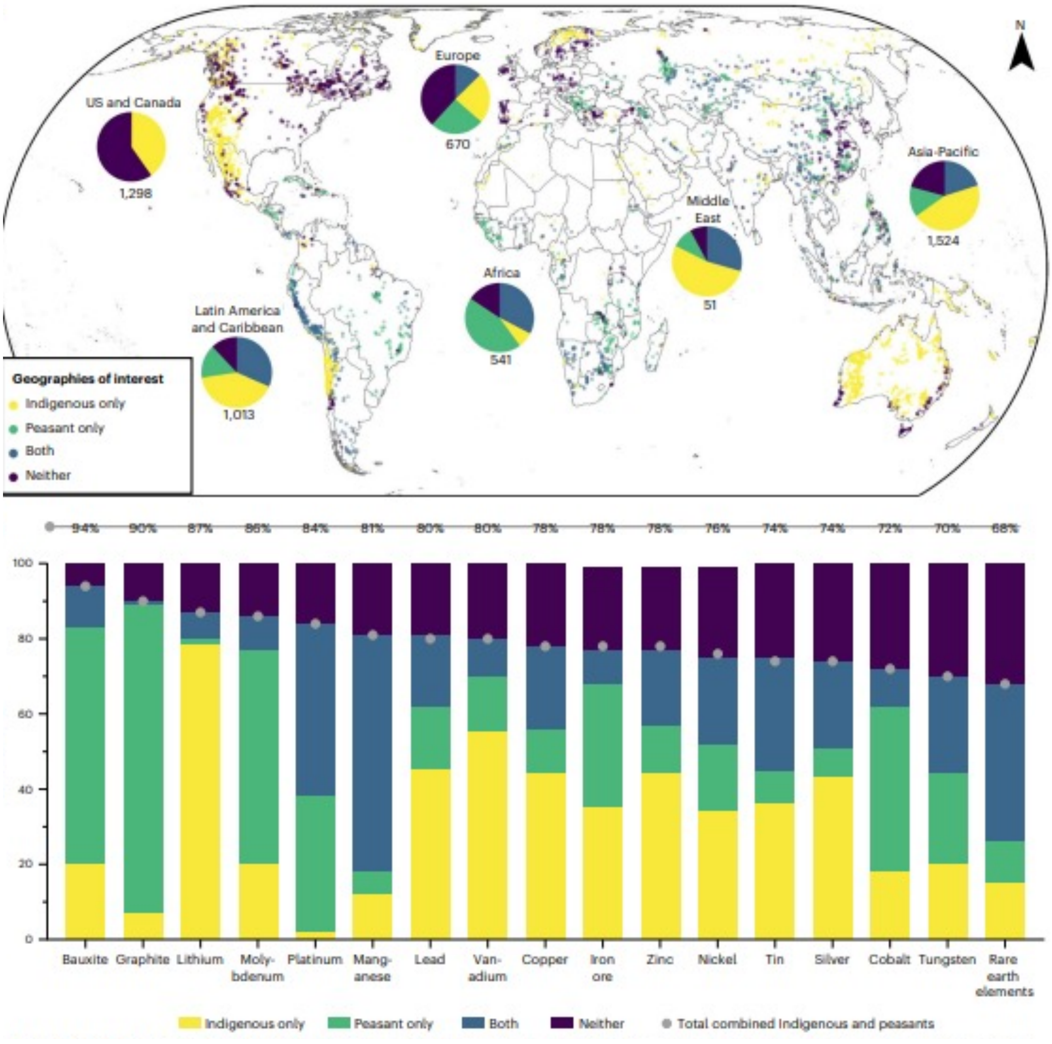



*Figure 2.9: Distribution of ETMs (Energy and Transition Minerals and Metals Projects) by Indigenous Peoples' and Peasant Land. Source: Owen et al (2023).[140]*

iv For example, the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) and ILO Convention No. 169 on Indigenous and Tribal Peoples, United Nations human rights treaties, regional human rights conventions, like the American Convention on Human Rights, the African Charter on Human and Peoples' Rights, as well as national constitutions and judicial decisions all provide some measure of protection.

v For an overview, see: State-of-Worlds-Indigenous-Peoples-Vol-V-Final.pdf (un.org)

vi See e.g., the court decisions of the Inter-American Court of Human Rights: Saramaka vs Suriname; Sarayaku vs Ecuador; Q'eqchi Aguacaliente vs Guatemala; Kaliña and Lokono Peoples vs Suriname.

vii A peasant is any person who engages or who seeks to engage, alone, or in association with others or as a community, in smallscale agricultural production for subsistence and/or for the market, and who relies significantly, though not necessarily exclusively, on family or household labour and other non-monetized ways of organizing labour, and who has a special dependency on and attachment to the land." The united Nation's Declaration on Peasant's Rights (2022. Available at: 9781003139874_10.4324_9781003139874-9.indd (oapen.org) initiatives to ensure they contribute to "self-determined sustainable development."[143]

Indigenous rights abuses are of particular concern in relation to large-scale mining projects and, by one measurement, are the most common type of allegation in relation to mining.[152] The Transitions Minerals Tracker logged 61 allegations (10%) between 2010-2022 impacting Indigenous rights, including 36 alleged violations of their right to FPIC.[153]

IPs and other marginalised groups can have weaker representation and participation in decision-making processes regarding mining or development projects, and are more likely to be disenfranchised from political agencies. They may also be less able to access benefits from mining operations (e.g. employment, amenities, and opportunities arising from economic growth), and may be even more adversely affected by the in-migration of workers.[154]

Those defending their rights can be subjected to social stigmatisation, arbitrary criminalisation, intimidation and repression and violence. Between January 2015 and August 2022, 883 attacks of Indigenous defenders have been reported including killings, threats, arbitrary detention and strategic lawsuits against public participation (SLAPPs).[155] Of the 145 SLAPP cases identified from January 2015 to December 2021 in Latin America, 62 were faced by individuals and groups who has raised concerns about mining projects. In 2021, a senior government security chief in Guatemala was convicted of murdering a local Indigenous leader who opposed the development of Fenix mining project.[156] Lawsuits alleging the gang rape and murder of local Indigenous Peoples protesting against the mine have been lodged against Fenix mine in Guatemala in 2009.[157] A study exploring violence by Canadian mining companies in Latin America produced by the Justice and Corporate Accountability Project alleged that 28 Canadian mining companies were linked to 30 'targeted' deaths, 363 injuries during protests, and confrontations, and 709 cases of criminalisation.[158]

Whilst some companies implement good processes to ensure consultation, effective particpation in decision-making and FPIC with IPs, others do not. In some instances, the power imbalance between corporate interests and Indigenous Peoples or those advocating to uphold their rights may be actively maintained by those in power.[159] Based on studies that take into account Indigenous Peoples' views, strategies used in some instances by extractive industries in relation to Indigenous Peoples have been described as predatory behaviours[160] and have demonstrated "unmistakable evidence" of cultural or structural violence (including seeding community conflict).[159] Within this context, narratives in the mining sector remain focused on improving stakeholder engagement, social license to operate, building trust, and managing community conflict, rather than on the issue of companies and governments failing to uphold their obligations, responsibilities and commitments to human rights.

**Box 9: Destruction of Indigenous Heritage in Australia**

In 2020, parts of the Juukan gorge in Western Australia were blown up by Rio Tinto in the pursuit of iron ore.[161] The specific rock that was destroyed was 46,000 years old and the only inland site in Australia to show signs of continual human occupation through the last ice age. Its destruction sparked a global uproar, leading to the resignation of three senior leaders and two board members of Rio Tinto. Whilst Rio Tinto was directly to blame, the incident shed light on Australia's outdated cultural heritage legislation, namely the Western Australian Aboriginal Heritage Act 1972 and Federal Aboriginal and Torres Strait Islander Heritage Act 1984 which allows developers to destroy Aboriginal sites provided they obtain approval from the minister for Aboriginal affairs.[162] Even though the Western Australia Aboriginal Heritage Act has since been amended to require developers to consult with Traditional Owners via new governance structures, the final decision on whether the land can be developed and/or destroyed still rests with the state minister, who will invariably have to consider competing priorities.[163]

### Box 10: Investor-State Dispute Settlements

According to a recent UN report, Investor-State Dispute Settlement (ISDS) has become a "major obstacle" in upholding human rights, which includes cases related to mining projects.[164] For example, Glencore has brought an ISDS case against Columbia following a Constitutional Court ruling that aimed to protect local communities and their environment from an expansion of Cerrejón, which is the largest open-pit coal mine in Latin America.[165] The mining company previously won a separate US$19 million claim against Colombia. ISDS mechanisms are embedded in international investment treaties, and are used to challenge state action, often to limit environmental or social harms caused by resource extraction, that may negatively impact foreign investor interests.[166] In addition to over-riding human rights, this is also thwarting environmental goals. For example the sixth assessment report of the Intergovernmental Panel on Climate Change (IPCC) has identified these treaties as limiting many states' ability to cut emissions.[167] Moreover, the views of third parties, including Indigenous Peoples and other local people who are often primary rights holders in the claims, often have limited particpation in these processes,[166] which the UN report argues is in itself a violation of FPIC. As such, there have been calls for reform of international trade and investment treaties to better align them with sustainable development goals, including through removal of ISDS mechanisms.[166,164]

## Case Study 9: Canada's Efforts to Boost Responsible Mining

The Canadian Minerals and Metals Plan aims to "build a socially, economically and environmentally sustainable and prosperous mining industry, underpinned by political and community consensus."[168] Canada has a Responsible Business Conduct Abroad Strategy[169] and is a member of the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High Risk Areas.[170]

Implemented by the Impact Assessment Agency of Canada, the Impact Assessment Act outlines the federal processes for assessing the impacts of major projects on federal lands or outside of Canada.[171] The Physical Activities Regulation outlines that the Impact Assessment Act applies to mining.[172] The act aims to foster sustainability, respect Indigenous rights, ensure equity and efficiency, encourage public engagement, incorporate Indigenous and scientific knowledge and assess cumulative regional effects.[171]

With regards to Indigenous, land and resource rights, Canada's National Benefits-Sharing Framework aims, "To address the barriers preventing Indigenous Peoples from fully benefiting from Canada's natural resources sector."[168] Canada has created a national engagement plan to encourage opportunities for regular discussion and collaboration between Canada's Indigenous People groups and the Canadian government.[173] The framework is centred around the pillars of capacity, inclusion, partnerships, and economic benefits. Furthermore, Canada's 'Implementing the United Nations Declaration on the Rights of Indigenous Peoples Act' requires, through consultation with Indigenous People, the federal government to create an action plan to ensure Indigenous rights are protected and advanced.[174,175] Canada also has various regulations in place to manage the social impacts of the mining industry. The Fighting Against Forced Labour and Child Labour in Supply Chains Act requires that government institutions report on steps taken, and processes in place, to mitigate against the risk of forced or child labour in supply chains.[176] Since 2019, British Colombia has aligned its laws with UNDRIP, including requiring FPIC for IPs, with the Eskay Creek mining project being the first mine developed subject to this law.[177]

Beyond government regulation, the Mining Association of Canada's 'Towards Sustainable Mining Initiative' provides a set of indicators and tools to allow mining companies to measure their ESG performance.[178] The indicators measure engagement in aboriginal and community outreach, crisis management planning, safety and health, tailings management, biodiversity conservation management, energy use and GHG emissions management. As aboriginal rights are enshrined in the Canadian constitution, the rights of aboriginal communities have generally been upheld by the supreme court in relation to mining.[179]

Despite these efforts, whilst few controversies are reported in Canada, Canadian mining companies have been linked to human rights abuses in other operating countries.[180,181] For instance, around 10% of the allegations documented by the Transition Minerals Tracker concern Canadian companies and in the DRC, Ivanhoe Mines, a Canadian mining company, are reported to have forcefully evicted many families in 2017 for the Kakula copper mine development.[182] This eviction is also reported to have been associated with sexual assault, arson and physical violence.

## 2.3.3. Labour Rights

Millions are employed by the mining sector. Precise numbers are difficult to estimate but, as mentioned previously, in the US the mining industry accounted for 1.2 million jobs in 2021[14] while in Chile, there was a 38% growth in employment in direct mining operations between 2020-2024.[15] The number directly employed by the sector can be multiplied many times over when indirect employment is taken into account (e.g. in the provision of goods and services).[13]

There are numerous examples of mining companies implementing rigorous health and safety programmes, robust local hiring initiatives, and supporting unions. However, mining has historically been a high-risk profession with hazardous working conditions and low pay. With millions of jobs and hundreds or even thousands of employers spread across multiple countries with very different labour laws and regulations, labour rights remain a critical issue for the mining sector. The most widely-discussed labour rights issues for the sector include occupational health and safety, working conditions and pay, non-discrimination and equal opportunity, collective bargaining and freedom of association and forced labour.

### Occupational Health & Safety

Over recent decades, there has been a concerted global effort to strengthen occupational health and safety (OHS) in mining operations, including through development of stringent regulations and global standards, and active company management. This has resulted in substantial reductions in accidents in fatalities, for example from nearly 250 fatalities in 1978 to 42 in 2023.[183]

According to the ILO, in 2015 the mining sector was responsible for around 8% of fatal accidents at work despite accounting for only around 1% of the global workforce.[184] This rate varies considerably by jurisdiction. For example, in the US the extractive sector has a fatality rate of 17 per 100,000 workers.[185] In the EU, fatalities in the sector are much lower than a range of other sectors, and considerably lower than in construction, transportation and manufacturing.186 By contrast, In Indonesia, mining is the most dangerous sector for labourers, causing 224 deaths between 2012-2022.[187] Work related deaths and labour rights abuses at Chinese-owned mine sites and processing plants in Indonesia have received specific attention. Between 2018- 2022 there were 15 deaths and 41 injuries at the PT Indonesia Morowali Plant.[188] In 2023, an explosion at a Chinese-funded nickel processing plant, in the Morowali Industrial Park had a reported death toll of approximately 13 people, injuring 38.[189] At the PT Gunbuster Nickel Industry smelter in Morowali, it was reported that employees were required to buy their own PPE.[188] In 2014, 301 Turkish miners were killed by an explosion at Soma mine, which an independent expert review blamed on serious failings in health and safety.[190] Since then, at least two further serious mining disasters at a coal mine and gold mine in Turkey have resulted in the deaths of 41 and 9 people, respectively.[191]

ICCMM's annual health and safety report for the mining industry shows a general downward trend in injuries (see also Figure 2.10).[192] However, the catastrophic Brumadinho dam failure in 2019 which killed 270 people, the majority of whom were workers, demonstrates the on-going scale of risks to human life from mining operations.

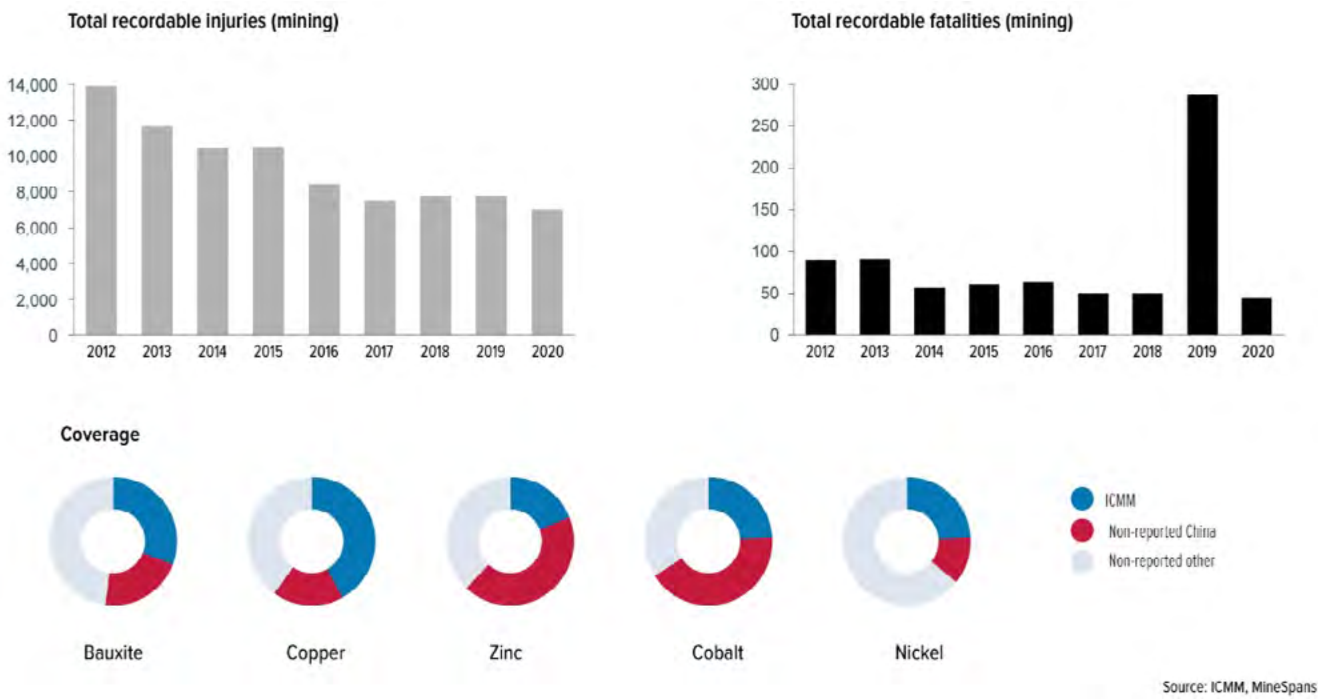



*Figure 2.10. Injuries and Fatalities in Mining. Source: Gregoir & Acker (2022).[97]*

## Working Conditions and Pay

As with all other areas of labour rights, working conditions and pay vary across companies and jurisdictions. In the US, for example mining is a relatively high wage sector, which may serve as compensation for relatively adverse working conditions.[193]

However, there is still room for improvement. In relation to working conditions indicators, the RMI 2022 found an average performance across the assessment criteria of only 30%.[149] A collective score of 74% across all companies assessed, when all good practices across companies were aggregated, demonstrated that practices do exist that could enable all companies to enhance performance in this area. Although the RMI report acknowledges "significant improvements" in working conditions over the last few years, the assessment found that none of the 37 companies assessed could demonstrate that they are "tracking, disclosing and reviewing worker ages against living wage standards."

Research over two years focused on five of the world's largest copper and cobalt mines by a UK-based corporate watchdog found numerous examples of labour rights abuses in large-scale mining, including the absence of a 'living wage', limited or no health provision, excessive working hours and unsafe working conditions.[194]

Sub-contracted workers are particularly vulnerable to poor conditions and an increase in the use of sub-contractors has been reported in the sector, potentially exposing workers to more precarious working conditions.[195–197] Poor working conditions of sub-contracted mine workers recently led to one company being added to the Brazilian government's "dirty list", a registry of companies that subject their workers to conditions comparable with slavery.[198] A rise in sub-contracted workers increases the potential for violations of the right of workers to freedom of association, collective bargaining and, in turn, discrimination against sub-contracted workers doing the same job.[199]

## Non-discrimination and Equal Opportunity

The proportion of women on boards of the top 500 listed companies globally increased by 13% from 2012 to 2024.[200] A McKinsey global survey found that multiple companies have boosted the percentage of women in their workforces over a period of three years, with one company achieving a rate of 32% of women in the workforce.[208] This represents noteworthy progress, but mining lags behind other industries in terms of female participation rates (Figure 2.11).[201]

In 2022, women were estimated to comprise only 12% of the global industrial mining workforce.[202] In Australia, the sector ranks second for the lowest female employer. Women's representation in Canada's mining industry has remained dormant at around 14% and 16% over the last few decades.[203] In 2019, women represented less than 10% of the total mining workforce in Indonesia.[204] Women working in Indonesia's mining industry are also reported to receive additional work, verbal harassment and other forms of discrimination in the work environment.[205] A deep dive into workplace culture at Rio Tinto documented cases of sexual harassment and everyday sexism as commonplace[206] whilst a similar review at Goldfields also identified everyday sexism and numerous examples of sexual harassment.[207] A 2024 review of violence against women in mining concluded that, "Energy transition gains are hampered in the light of unresolved cases of violence in mining areas."[208]

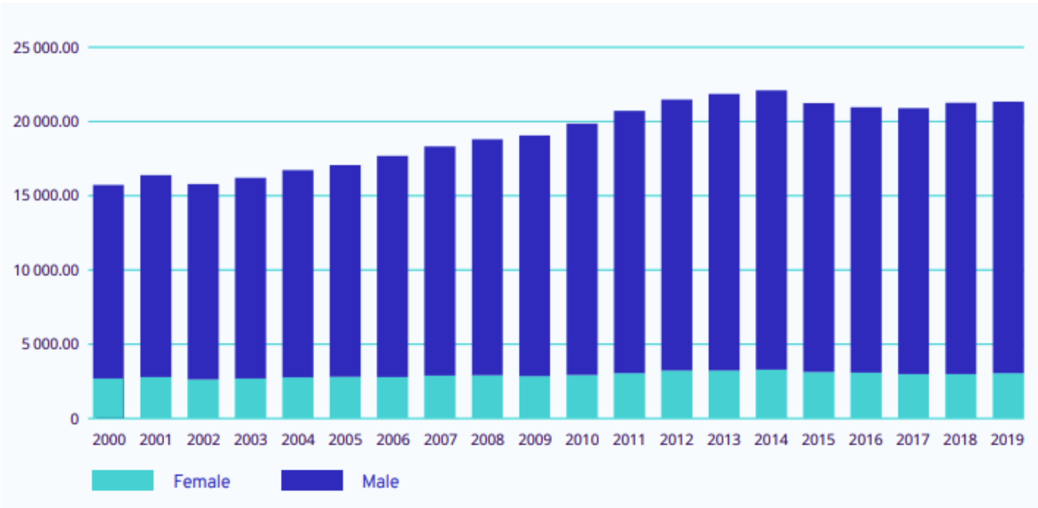



*Figure 2.11. Mining Employment, by Sex, 2000–2019 (thousands). Source: ILO (2021).[209]*

Note: These estimates are based on data collected by ILO Member States. Given the informal nature of ASM, the data collected are likely to exclude large numbers of women and men in ASM.
Source: ILO, n.d.-b.

Racial discrimination in the workplace is also prevalent in the mining sector. For example, a report on the cobalt sector in the DRC found multiple examples of racism, discrimination and degrading treatment of Congolese workers.[194] Another found that a range of different groups in Rio Tinto's workforce, particularly Australian Aboriginal and Torres Strait Islander employees in Australia, reported experiencing racism in the workplace.[206] In total 15% of Goldfield's employees reported experiencing racism in the previous five years.[207] Further reports also document that Lesbian, Gay, Bisexual, Trans, Queer, Intersex, Asexual and other (LGBTQIA+) individuals are experiencing discrimination in the workplace in the sector.[210–212] Although Indigenous Groups are well-represented in Canada's mining sector, comprising around 10% of the workforce in 2023 (compared to around 4% across all industries), Indigenous People tend to be employed in a narrow range of production, trades and support-worker roles that require lower educational attainment, and are subject to less stability.[203]

### Forced Labour

Mining accounts for a relatively small share of the approximate 17.3 million people in forced labour (the majority of whom work in services, manufacturing, agriculture and construction).

However the ILO estimated (2022) that there are nearly 250,000 adult workers forced to perform mining and quarrying work.[213] ILAB's List of Goods Made by Child Labor or Forced Labor[214] and the List of Products Produced by Forced or Indentured Child Labor[215] document child labour or forced labour in the production of a range of minerals and metals in 35 countries.[216] A recent lawsuit linked mining of cobalt used by in China's Xinjiang Region, which has been at the centre of multiple human rights allegations including forced labour.[218] The push by the Chinese government to make Xinjiang an industrial hub means that car makers will be increasingly exposed to human rights risks in their global supply chains.[93,218] Gold mining in Xinjiang has also been linked to forced labour.[218] A 2023 report by the Centre for Advanced Defense Studies revealed that the working conditions of many gold miners were "akin to slavery" and identified 420 western companies connected to the region.[219]

### Collective Bargaining and Freedom of Association

Collective bargaining is the primary mechanism that employees and trade unions can use to settle conflict about employment-related issues. In some locations the freedom of association of workers is limited, seen by governments or business as a barrier to economic growth. The remoteness of mining operations and lack of alternative sources of employment, can create surplus labour supply, weakening the position of workers seeking to uphold their rights to collective bargaining; while workers who have migrated to the mining area may also be excluded from unions and collective bargaining mechanisms as a result of discrimination or language barriers.[220]

An investigation into DRC's copper cobalt mines found that the use of subcontractors is at the core of exploitation of worker's rights, including severely limiting access to collective bargaining via unions to raise concerns.194 This is also reported to be common in the sector for sub-contacted employees in other countries, for example Peru, Colombia,[199] Canada[195] and South Africa.[197]

## 2.3.4. In-migration

In-migration is a key issue, especially where mining is the main source of economic activity in an area. Many of these impacts can be positive. The arrival of hundreds, if not thousands, of new people including employees, contractors and migrants, can act as a stimulus to local economies, sustaining existing businesses and creating new opportunities. Most obviously, landowners, hotels, shops, restaurants, bars and street traders all stand to gain. In-migration can also increase the local skills base, open up new opportunities for local products and services, and stimulate the expansion of new infrastructure and public services.

The adverse impacts can be equally substantial. The economic impacts of in-migration are unlikely to be uniformly positive: some will benefit, others will lose out. Migrants bring competition: for jobs, for markets, for housing and for resources. Local businesses may find themselves undercut and inflation is a common side effect of in-migration with rising prices for staple goods and basic utilities such as electricity.

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viii Owned or operated by LSM companies including Glencore's Kamoto Copper Company, Eurasian Resources Group's Metalkol RTR, China Molybdenum's Tenke Fungurume Mining (TFM), China Nonferrous Metal Mining Company (CNMC)'s Société minière de Deziwa (Somidez) of which the Congolese state company Gécamines owns 49%, and Sino-congolaise des mines (Sicomines) a joint venture between Gécamines and a consortium of Chinese companies and investors.

ix Coal, cobalt, copper, diamonds, fluorspar, gold, gypsum, iron, mica, polysilicon, silver, tantalum/coltan, tin, trona, tungsten and zinc.

x Afghanistan, Angola, Bolivia, Burkina Faso, Cameroon, the Central African Republic, China, Colombia, the Democratic Republic of Congo, Ecuador, Ethiopia, Ghana, Guinea, India, Indonesia, Kenya, Liberia, Madagascar, Mali, Mongolia, Nicaragua, Niger, Nigeria, North Korea, Pakistan, Peru, the Philippines, Senegal, Sierra Leone, Sudan, Suriname, Tanzania, Uganda, Ukraine and Zimbabwe.

The uneven spread of economic benefits can become a source of tension within communities and between communities and migrants. Tensions can be exacerbated if there are historic or ethnic differences between host communities and outsiders and locals perceive that migrants are capturing benefits at their expense.

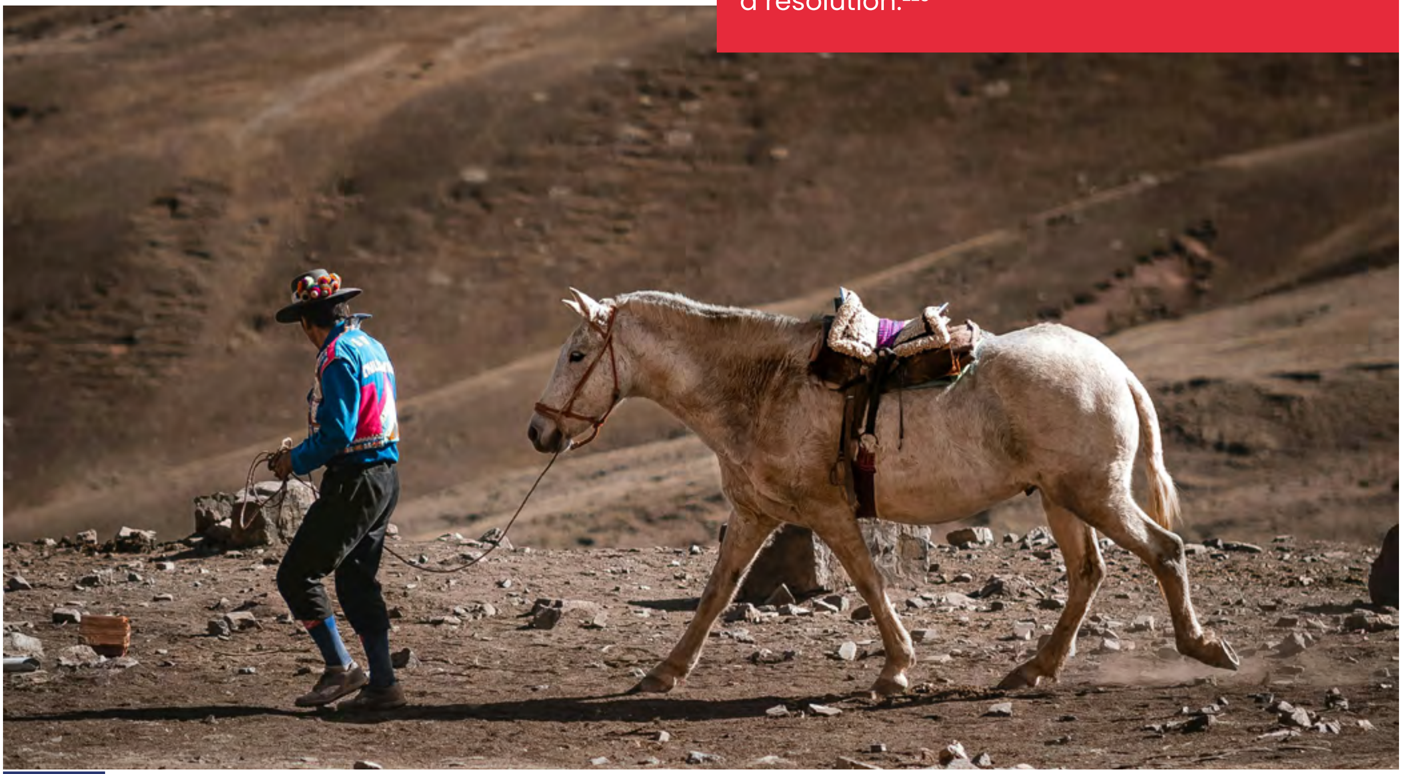
Beyond competition for jobs and markets, in-migration can put pressure on land, housing and access to clean water or can result in damage to forests, biodiversity and other natural resources. The arrival of so many people from outside the local area can also have an impact on culture and social cohesion, disrupt established social norms and behaviour, potentially creating tension, anger and conflicts with host populations.[16,220] In-coming migrants can bring infectious diseases, unplanned squatter settlements can create health and hygiene risks from poor sanitation, and greater demand can strain existing healthcare services, and prostitution, gambling and crime often increase with the potential to overwhelm local police forces.[221]

Increased rates of violence towards Indigenous Communities and rates of Missing and Murdered Indigenous Women and Children have been where there has been in-migration associated with extractive industries.[222–224] The creation of temporary 'man camps' has been linked to increases in violent crime (towards both and women, and particularly minority groups) and to having harmful impacts on communities long-term.[225], A World Bank funded study also highlighted the adverse impacts of increased crime, alcoholism and gender-based violence in new mining areas on women in Indonesia.[226]

## Case Study 10: Impacts of Mining Generating Social Conflict in Peru

EITI report that more than 80% of documented environmental/social conflicts in the country are related to the mining sector.[227] Peru has the highest number of reported human rights abuse allegations in the Business and Human Rights Resource Center's Transition Minerals Tracker.[153] This is dominated by strategic lawsuits against public participation (SLAPPs) and by Las Bambas copper mine in Peru. According to the Transitions Minerals Tracker, "Over the years, the mine has allegedly caused a series of environmental and human rights impacts, the site has been described as operating in a constant state of conflict with allegations including forced relocation, violent repression of Indigenous and peasant communities protesting against the mine, and construction of a road across community lands without prior consultation, illustrating how superficial community engagement can have significant consequences for operations and threaten to derail the global supply of one of the most critical minerals."[153]

In recent years, several projects, totalling an investment of US $12 billion, have been put on hold due to conflicts over social impacts.[11] In April 2022, protests were held at key mines across Peru, affecting 20% of Peru's national copper output.[228] Protesters complained that despite high global prices, nearby communities do not receive enough financial compensation, therefore demanding a share of future profits. As a result, the prime minister declared a state of emergency to restore copper production in Cuajone mine after negotiations failed to reach a resolution.[228]



## 2.3.5. Conflict Over Resources

Mining's strategic and economic importance adds value and can have unintended consequences. Millions benefit from the production, the proceeds and the output, but who benefits and how is also a source of intense competition and conflict. The burdens and benefits of mining are unevenly distributed. At a global level, those in developed nations tend to benefit most from mined resources, while the costs are largely borne by those living closest to mining operations, often in less developed countries. UNEP (2024) estimates that high-income countries use six times more materials per capita and are responsible for ten times more climate impacts per capita than low-income countries.[229]

At a national level, financial benefits disproportionately flow to mining companies (often foreign-owned) and national governments, while those living in proximity to mine sites tend to absorb the adverse impacts while receiving fewer of the benefits. The inequitable distribution of the economic proceeds of mining is a key cause of tensions and sometimes leads to conflict.[16,230] For example, First Quantum's copper mining operations in Panama account for 5% of the country's GDP and 75% of its export earnings, yet it is reported that few of these economic benefits are felt locally, recently leading to mass protests.[231,232]

Locally, there are several sources of conflict arising from mining activities, many of which have been described earlier in this section. Competition over the ownership, access to, use, or sharing of natural resources underpins the disputes over the allocation of benefits. In the worst cases, the result is protest, sometimes violent.

## 2.3.6. Human Rights in Artisanal and Small-scale Mining (ASM)

Those working in ASM represent the largest workforce within the sector. In 2013, the ILO estimated an ASM workforce of 13 million.[233] In 2017, it was thought to employ around 40 million people, compared with just seven million in industrial mining.[234] Currently, according to the Artisanal Mining Inventory (Figure 2.12),[235] there are more than an estimated 49.5 million individuals directly engaged in ASM across 85 countries (26% women, 37% in gold mining), with evidence of ASM also taking place in a further 20 countries (and indications it is likely to be taking place in a further 14 countries). The most ASM miners are found in India (15-18m), China (7-15m), Indonesia (3.5-3.7m) and DRC (600k-2.5m).[236]

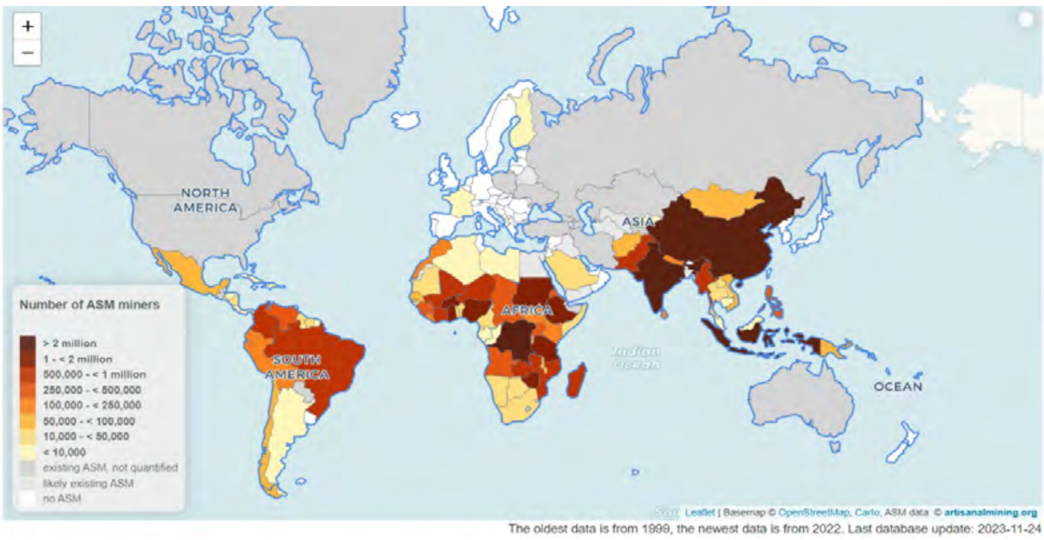



*Figure 2.12. Number of ASM Miners per Country. Source: The Artisanal and Small-scale Mining Knowledge Sharing Archive (n.d.).[235]*

Many human rights abuses, such as child labour, forced labour, and hazardous working conditions, are of particular concern in ASM mines.[97, 237] It is estimated that around 8% of the ASM workforce is operating illegally.[238] ASM operations can also become entangled with other illegal activities.[237] In these contexts, threats of violence and the use of bribery can cause wider damage to communities, and can be linked to prostitution, child labour and substance abuse.[239] For example, in South Africa, illegal and informal mining is thought to have created a "lucrative secondary informal syndicate market supplying commodities, including food, liquor and prostitutes."[239]

## Child Labour

The incidence of child labour in the mining sector, mainly in ASM, is high.[220] The ILO estimates that over a million children are engaged in child labour in the sector.[240] Child workers are at risk of exploitation, physical and psychological abuse, and are subjected to working conditions where physical strain and chemical exposures may result in lifelong disabilities.[241] They tend to have limited or no access to education. [220]

This problem is particularly acute in certain geographies but is a global issue. For example in 2006 the ILO estimated that 30-50% of the gold mining workforce in Burkina Faso and Niger were under fifteen, with a proportion under conditions of forced labour.[242] In the DRC, surveys have found children working in almost a third of ASM sites visited.[243] A recent ILO report states that "according to the 2016 US Department of Labour List of Goods produced with Child Labour and Forced Labour, child labour was used in the production of 29 goods produced in quarries and mines in 34 countries across Africa, Asia and Latin America."[240] As a result of the reported use of forced labour including child labour in REE production, Apple pledged in 2017 to move away from sourcing REEs from Ganzhou. Policy responses need to be grounded in comprehensive and effective approaches in vulnerable contexts so that withdrawal of employment does not simply drive children into worse forms of child labour, such as sex work.

## Forced Labour

It is challenging to find statistics for forced labour in ASM as it often occurs in remote areas where governance is weak and mining activities are challenging to monitor.[244] However, cases are found in all regions, reported either in small-scale mining or in low-skilled occupations in the sector.[245,246] Mining of cobalt in DRC has been linked to forced labour[247] while different forms of labour exploitation have been evidenced in in Peru, Colombia, Suriname, Mali and the Democratic Republic of Congo, amongst others.[244] Forced labour is also associated indirectly with ASM as a result of in-migration that creates and attracts informal and high-risk services, exposing adults and children to exploitation.[244]

## Occupational Health and Safety

ASM workers are exposed to multiple toxic hazards, most notably mercury, lead, cyanide, arsenic, cadmium and cobalt. They also face physical hazards, most notably accidents, airborne dust and noise, and are at high risk of infectious diseases.[241] Many ASM workers often work in hand-dug underground tunnels without adequate safety equipment, facing constant risk of cave-ins or landslides, resulting in suffocation or drowning.[248] For gold-related ASM alone, the WHO (2016) identifies 22 sources of hazards across chemical, biological, biomechanical, physical and psychosocial categories, resulting in a multitude of adverse health outcomes. Mercury is frequently used in ASM and presents a serious risk to the health of workers and communities, with children and pregnant women particularly vulnerable to the adverse neurological effects of exposure.[249] However, injuries and fatalities and chronic diseases associated with ASM are poorly documented and the scale of health impacts therefore challenging to determine.[241]

On the whole, health hazards are poorly managed in most ASM mines. A survey of ASM workers in the DRC found that the working conditions of most miners were "unacceptable", and that protective equipment used in only two of 58 the mine sites surveyed. Respondents reported over 60 fatal incidents and more than 100 incidents involving injury in the preceding year.[243] In Indonesia, a 2017 site-level analysis of ASM mining operations on the islands of Bangka and Belitung identified multiple occupational health and safety hazards, such as noise, sun and chemical exposure, drowning, poor water and sanitation, landslides, and engine operational injuries.[250] Between June 2018 and January 2022, landslides and poison gas have led to the death of over 150 illegal Indonesian miners alongside a handful of occupational injuries.[251]

## Gender Rights

Women play a critical role in the ASM sector, with at least 13.4 million women (on average, around 30% of the global ASM workforce).[233] Within ASM, women tend to undertake tasks that are less visible, e.g. preparing food, processing gold within the home, so this figure is likely an under-estimate. Women (and children) may be particularly vulnerable to potential health harms, often being employed in less physically demanding but as or more hazardous processing activities.[220] Women working in ASM may be subjected to sexual assault, violence and psychological abuse, and they often face discriminatory work practices.

## Indigenous, Land and Resource Rights

ASM mining also undermines Indigenous rights, particularly in the Amazon.[252] For example, a recent map identifies 2,312 illegal gold mining sites in 245 areas across six Amazon countries, with 37 of these in Indigenous Reserves.[253] In 2020, over half a million ASM gold miners were estimated to be active in the Amazon, with over 70% of the gold emerging from Colombia, Ecuador and Venezuela being produced illegally, and many Indigenous lands being affected by illegal mining.[252] This activity is growing, driven largely by rising gold prices coupled with limited alternative livelihood opportunities.[252] The impacts of artisanal and small-scale gold mining on Indigenous land rights, and in turn the social and health risks for Indigenous Peoples, is particularly well-documented in the Brazilian Amazon.[254,255]

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# 3. Institutional Investors' Role in Shaping the Mining Industry

The aim of this chapter is to identify where institutional investors could effect change in the mining industry. Institutional investors include both asset owners and asset managers. To understand the role of institutional investors, the following elements need to be considered:

- The mine lifecycle (from exploration to closure).
- The stakeholders involved at each stage of the mining lifecycle, including their activities, who is providing funding, who is impacted and affected, and who can effect change.
- Whether and how institutional investors can effect change in each stage of the lifecycle or stakeholder activities.

This section of the report is informed by a review of the available academic and industry literature (although there are many gaps in this literature), interviews with members of the finance and mining industries, and a survey of investors. The latter involved both investors supporting the Commission, and discussions with other institutional investors involved in the mining sector.

This chapter focuses on institutional investors and, given their scale and how they invest, has a relatively limited focus on ASM although many of the proposals remain directly relevant to ASM.

## 3.1. Financing Throughout the Mine Lifecycle

**Key Takeaways**

- At exploration, most companies involved are juniors. Institutional investors can engage with these actors via the majors to ensure adequate standards of social and environmental performance are met both by majors and juniors, and via stock exchanges to uphold clear expectations of companies.
- At feasibility stage, institutional investors can encourage private equity, venture capitalists, streaming companies and the development banks to adopt and enforce adequate standards of social and environmental performance.
- At the planning, design and construction stage, institutional investors can encourage private equity funds and public and private banks to adopt adequate standards of social and environmental performance when financing mining companies, and to ensure that performance against these standards is monitored and enforced.
- At the operational stage, institutional investors can engage with the listed major companies where they have a direct relationship. Here, investors can require companies and other financial institutions, e.g. banks and private equity investors, to adopt and enforce adequate standards of social and environmental performance. However, at this stage, given that the impacts may have already occurred in the earlier stages, and it is difficult to retrofit standards to an operational facility, there is less potential for investors to reduce impact.
- At mine closure, institutional investors are less influential given that the ownership and responsibility for these sites is often transferred to the state or to smaller companies. Institutional investors can, however, engage with mining companies earlier in the mine lifecycle to anticipate closure issues and challenges, to model closure and rehabilitation costs, and to explore post-closure opportunities in collaboration with affected stakeholders.

Identifying where investors can effect change in the mining industry, requires an understanding of the key actors that institutional investors interact with, and how. Mapping the financing flows demonstrates who funds and who receives the cash flows and other benefits from the mining industry. This in turn enables the identification of aspects of industry where investors could deploy leverage.

There are different financing models and timelines for each stage of the mine lifecycle. The timeframe can depend on the specific variables associated with each location, such as permitting, regulation, the commodity, geology, technical capacity and local stakeholders. Importantly, mining projects need to be financed all the way through the mine's lifecycle (Figure 3.1), noting that different financial actors are involved at different stages (as illustrated in Figure 3.2).


*Figure 3.1. The Mine Lifecycle.*

| Financiers | |
|---|---|
| **Major mining companies** | Stake/control |
| **Company self-finance** | Own revenue |
| **Royalty and streaming companies** | Cash payment for share of future production/revenue |
| **Retail / speciality investors / VCs** | Equity<br>Debt |
| **Institutional investors** | Equity<br>Debt |
| **Commodity traders** | Contracts |
| **Commercial banks** | Project finance<br>Loans |
| **Investment banks** | Hedging, advisory, debt |
| **Development banks** | Project finance<br>Grants |
| **Governments** | Debt<br>Grants |
| **Insurers** | Insurance, reinsurance |
| **Export Credit Agencies** | Loans<br>Insurance |

| Financed |
|---|
| **Juniors (exploration and production)** |
| **Mid-caps** |
| **Majors** |
| **State-owned** |

| Beneficiaries | |
|---|---|
| **Governments (Central, regional and local)** | Taxes<br>Royalties |
| **Contractors** | Contracts |
| **Suppliers (global and local procurement)** | Contracts |
| **Investors** | Dividends, debt |
| **Banks** | Interest |
| **Local communities** | Infrastructure investment<br>Local procurement |
| **Local workers** | Salaries and wages |
| **Downstream supply chain (from refiners – to OEMs and product manufacturers)** | Contracts |

*Figure 3.2: Financiers, Financed Organisations, and Beneficiaries for Large Scale Mining.*

## 3.1.1. Exploration

Exploration is a key and risky stage for financing. At this stage, **the largest share of entities involved in exploration are junior mining companies**. Juniors had a 43% share of the global exploration budget in 2021.[1] Early prospecting often consists of small teams of mainly geologists from these junior (small) explorat ion companies.[2]

The way exploration is conducted is key in setting the tone for interactions with potentially affected stakeholders and rightsholders. This influences perceptions of the project over the short and the long term.3 The actions of exploration companies can create expectations amongst people in the area about the potential benefits that will be delivered when the mine is operational, and if these expectations are not met, it could undermine trust in the project or lead to conflict.[2]

Raising funds for exploration is difficult as the companies involved are looking for unknown deposits and discovery is not guaranteed, nor can the point in time for discovery be scheduled. At this point, when making an investment decision, investors will focus on the governance of the company and the prospect of making a successful discovery in the location being explored.

The most common way for juniors to raise funds is to raise money via the public equity markets. As of May 2024, there were over 900 junior mining companies listed on the Toronto Stock Exchange's TSX Venture Exchange. This number excludes those in other jurisdictions such as Australia (ASX) or non-listed entities. In fact, estimates of the number of junior companies at the exploration stage go into the thousands.[4] Juniors can also raise funds from private investors.

Whilst most exploration is carried out by junior companies, **some major companies and mid-cap companies** are involved at this stage:

- **Company self-finance:** Major and mid-cap companies mostly explore on brownfield sites or near existing operations to increase life of mine. In some circumstances, mid-caps may go to royalty and streaming companies for funding to develop greenfield projects.
- **Relationship between majors and juniors:** In some cases, major mining companies invest in juniors for exploration. As part of the investment deal, the major might provide access to technical expertise (such as geologists, hydrologists and technologies). Some companies may require the junior to adopt the major's standards and practices on:[2]
  - Managing relationships with external stakeholders, including expectations set with local communities and informal transactions with government officials;
  - Having a technical or a sustainability committee;
  - Risk analysis;
  - Managing security;
  - Cost accounting;
  - Environmental and Social Impact Assessments.

### Institutional investor role at the exploration stage

There are few direct pressure points available to institutional investors to require companies to adopt ESG standards at the exploration phase. However, there are opportunities for institutional investors to effect change:

- **Majors:** Institutional investors can be invested in the major mining companies. When major mining companies partner with the junior companies, investors can press the majors to ensure the sustainability standards and performance of the junior mining company are adequate, and to impose the major's standards on the junior company.
- **Stock Exchanges:** Investors could encourage stock exchanges to have clear sustainability and transparency expectations of the junior mining companies that are listed, and to provide tailored guidance on managing ESG-related issues.

**Box 11: Insurance**

Insurance is required across the mine lifecycle. It varies depending on what needs to be insured: the actual asset, business interruption and liabilities. Policies are normally issued for one year. An insurance company's aim is to identify whether there are any aspects which are likely to cause delay to or stop production and to ensure that the mine remains operational. The insurance company generally sends out surveyors to assess aspects such as the physical and natural aspects of risk, and infrastructure stability.

As a result of these assessments, insurers may ask companies to make changes within a certain timeframe, either as a condition of issuing insurance or to reduce the insurance premium.

Sometimes, local insurance companies cannot manage the risk and require reinsurance to take on the risk. In some cases, miners may opt for self-insurance[5] if they consider the costs of third-party insurance to be too high or the conditions are too burdensome.[6]

## 3.1.2. Feasibility

At the feasibility stage, companies need to conduct three studies:

1. **Concept study:** This is the cheapest study and is often financed using funds raised from the exploration phase. This study describes the resource with some basic plan of how to develop it.
2. **Pre-feasibility study:** This study includes preliminary design features such as processing and tailings storage options.
3. **Feasibility study:** This is typically a comprehensive and robust study of all features of designing and planning a mine. It covers issues such as: mining methods (open pit or underground), processing plant design, waste treatment and disposal, labour agreements, safety, health and environmental requirements, logistics and supply chain management, risk controls, capital costs, duration of construction, operating costs, production volumes, cash flows, tax and royalty payments and project valuations.[7]

Major mining companies generally self-finance these studies. Juniors and mid-caps will tend to get their funding from private equity and venture capitalists as well as royalty and streaming companies. Development banks can also finance, in whole or in part, the studies. Generally the development banks will use their own standards to assess the project.

#### Institutional investor role

Institutional investors could engage with private equity, venture capitalists, royalty and streaming companies and with development banks to understand the current standards being imposed on the industry and to set expectations for mining companies. Some royalty and streaming companies, such as Franco Nevada and Wheaton, are listed companies themselves opening themselves up for shareholder engagement. Many development banks have already defined their sustainability standards and expectations, and impose these on companies. The asset owners (or limited partners) investing in the private equity fund can also require certain standards. Ensuring that these standards are robust and consistently applied are potential areas of focus for institutions investors.

### 3.1.3. Planning, design and construction

Whilst this stage is relatively short, the construction phase is where significant and visible impacts on the environment occur as major infrastructure, ancillary facilities and access works are set up.[2] It is also where many social issues appear. Construction potentially creates job opportunities but can also result in substantial social changes (e.g. through allowing access to once remote areas, through the development of infrastructure or through increasing in-migration).[3]

Mine construction is often carried out by a contractor, supported by a variety of specialist and general sub-contractors. For contractors, the primary goal is to fulfil the contract to time and budget. While lenders or the project owner may stipulate ESG measures in contracts, the effectiveness of these measures depends on implementation, monitoring, evaluation and accountability processes. Their effectiveness is also critically dependent on the extent to which cost and delivery schedule-related considerations drive day-to-day decision-making.

In terms of financing:

- This is the stage of mine life that requires a large amount of funding, and likely most mining companies will go to external sources, even the majors. Thus, this is a pivotal point and is likely the most effective place to promulgate meaningful change.
- If development banks finance the feasibility studies, they may also provide some funding through to the construction phase.
- For juniors, some of their capital requirements may be met by banks.
- Mid-caps may sell a part of the project to investors to raise funds. Where they already have a sizeable proportion of the funds required and need to raise smaller amounts, they often go for project financing or to royalty and streaming companies.

#### Institutional investor role

Institutional investors can ask other investment funds and banks to adopt adequate standards of social and environmental performance when financing mining companies, and to ensure that performance against these standards is independently audited, monitored, disclosed and enforced. Private equity can also encourage the implementation of certain standards by the mining companies they invest in.

### 3.1.4. Operations

Once a company starts producing, it starts generating a revenue. There are two broad types of capital at this stage:

- **Sustaining capital:** for maintenance and upgrades. This is generally funded by the company itself or project linked loans can be issued.
- **Growth capital:** for expansion or a major project where the major or mid-tier company does not want to fund it from their own capital. Companies' options can include sourcing finance from:
  - Joint Ventures: another company to enter into operations with.
  - Commercial banks: debt funding.
  - Development banks: project finance and grants.
  - Investment banks: hedging, advisory and debt.
  - Royalty and streaming companies.
  - Governments: State-owned companies can receive grants or debt funding.
  - Listed equity: Institutional investors buy and sell shares in companies.
  - Private equity: Equity.

#### Institutional investor role

At the operational stage, institutional investors can engage with the listed major companies where they have a direct relationship. Investors can encourage these companies to adopt adequate standards of social and environmental performance and to ensure that performance against these standards is monitored and enforced. However at this stage, it is difficult to retrofit standards to an operational facility, so there is less potential for investors to reduce negative impacts that have already occurred.

Private equity investors also work closely with investee mining companies. They, like institutional investors, have an important role to play in encouraging mining companies to adopt adequate standards of social and environmental performance, and to ensure the effective implementation of these. Institutional investors are important investors in private equity, and should therefore press private equity investors to ensure the adoption and effective implementation of adequate social and environmental performance standards. Institutional investors should be prepared to reduce or withdraw their investments if private equity firms cannot meet their expectations.

Investors can also encourage other financiers at the operational stage, namely banks, to uphold a high level of standards and expectations. Institutional investors should encourage performance against accepted standards to be independently audited and findings disclosed.

### 3.1.5. Closure and Post-Closure

Mine closure requires advanced design, planning, approvals, decision-making, and implementation. Post-closure processes are intended to prepare the site for the long term, and include site rehabilitation, the monitoring of ecological and social conditions, and the development of post-mining land uses.[8] The closure and post-closure phases can create significant costs, risks and opportunities as impacts can run in perpetuity.

At this stage of the mining life-cycle, private finance tends to have limited involvement. Financial assurance by the mining company is required to ensure the host country does not inherit the site liabilities without corresponding finance to address these liabilities. Mining companies should have a comprehensive closure plan outlining the costs associated with closure, and how these costs are to be met (e.g. through insurance, through the revenues generated in the operational phase, through some form of closure bond).

Closure is challenging. There have been many cases where closure provisions have been inadequate, and many cases where the operator has sold (disposed of) the mine ahead of closure leaving a smaller, poorly capitalised operator with responsibility for paying for mine closure. Unsurprisingly, many of these smaller operators end up in bankruptcy, leaving government with the responsibility (and liability) for closure and rehabilitation.

Governments have tried to manage the risks in closure through measures such as:

- Asset retirement obligations which designate what the liabilities are for closure. While these seek to address some of the issues with mining closure, there is limited information on their effectiveness.
- In North America, regulators issue an exit ticket which allows the company to return the land to the government post-closure. The costs should be included in closure planning with a general window of four years for issues to play out. If the stability of the site cannot be proved or predicted, then it is more challenging for the company to obtain the exit ticket.

**Box 12: Challenges with accounting for closure**

Mining companies need to make financial provisions for closing a mine site. There are various types of cost estimates:[9]

- **Life of Asset closure cost estimate:** costs that the operator expects to incur in the context of the current mine plan at the end of the mine life.
- **Financial liability closure cost estimate:** estimated liability based on applicable accounting requirements.
- **Sudden closure cost estimate:** cost to close the operation in its current state.
- **Regulator closure cost estimate (financial assurance):** costs that form the basis of a guarantee provided to a regulatory body based on an approved closure plan.

In practice, cost estimation models are often designed for regulatory closure cost estimates, which means that the full life of asset closure costs are not necessarily properly accounted for.[10] The challenge is needing to predict actual site conditions for a future point in time.[11] Most jurisdictions mandate closure cost estimations to be based on current conditions/ prices; with regular review and updates.[10]

#### Institutional investor role

Institutional investors could engage with mining companies in the earlier stages to anticipate closure issues and challenges, and to model/ estimate closure costs. This includes being considered in the design criteria of the mine site, when the projects are developed, and during the operational stage. Opportunities for the land post-closure could also be discussed in collaboration with other stakeholders such as governments and communities, as could the opportunities for investment in alternative economic activities or restoration.

## 3.2. Stakeholders in the Mining Industry

**Key Takeaways**

- The mining value chain is complex. Stakeholders include mining companies (juniors, intermediaries, majors and state-owned enterprises), processing companies, commodity traders, artisanal and small-scale miners, transport and logistics companies and end-user companies.
- National, regional and local government have different roles and influence over the mining industry and the trade of commodities, via permitting and licencing, import and export rules, taxation, revenue sharing and benefit distribution.
- Stakeholders in mining areas can benefit from and be negatively affected by the social and environmental impacts of mining. How these costs and benefits are determined and distributed can impact stakeholder responses. Poor engagement processes and negative impacts can generate conflict and prevent or delay production.

Understanding the multiple stakeholders in the mining industry is not restricted to value chain companies (see Figure 3.3), but also requires consideration of a wider range of stakeholders that are affected (positively or negatively) by mining operations at different scales, e.g. local rightsholders or governments. These stakeholders are outlined in this section.

| Value-chain step | Mine | Processing plant | Inventory | Rail | Port | Ship | Market |
|---|---|---|---|---|---|---|---|
| Activity | Extracting materials (eg, with shovels, excavators) | Processing the raw materials | Managing inventory levels and quality | Moving materials to the port | Stockpiling, loading, and managing vessels | Shipping materials to destination | Delivering the materials to the customer |

*Figure 3.3. Mine to Market Value Chain. Source: McKinsey & Company (2020) The Mining Value Chain: A Hidden Gem.*

### 3.2.1. Mining Companies

Mining companies can be described in terms of size:[12]

- **Juniors** are typically involved in the exploration, scoping, feasibility and approval stages of mine development and, if listed, have a small market value (usually < US$1 billion).
- **Intermediary** or mid-tier companies are typically involved in mine development and production, and if listed will have a market value of <US$12 billion, will own more than one asset, and may be diversified in terms of mineral production.
- **Majors** are typically diversified and hold multiple assets, and, if listed, will have a market capitalisation of >US$12 billion.

While there are around fifty major mining companies, there are thousands of intermediaries and juniors.

Joint Ventures are not uncommon in the mining sector. Joint ventures allow companies to share capital costs, bring in expertise and to manage risk. However they have been criticised for ineffective and weak governance, poor transparency and a lack of accountability to investors.[13]

In terms of listed companies, a few countries dominate with most mining companies headquartered in Australia, Canada, China, Switzerland, the UK and the US. Based on mid-2010s figures, there are estimated to be approximately 25,000[4] mining companies operating in about 140 countries.[12]

**State-Owned Enterprises** (SOEs) control mining activities, both within their own countries and abroad. Countries with the highest levels of state-ownership of metal mining production are China, Chile and India.[14] China has the largest share of state-owned enterprises globally and these enterprises have invested widely abroad, especially in developing countries. Over the past decade, an average of US$75.5 million annually has been directed to exploration in Africa by Chinese state-owned companies.[15]

### 3.2.2. Artisanal and Small-scale Miners (ASM)

ASM is another key production source. While there are limited data, a 2004 study suggested that ASM provides 15-20% of global non-fuel mineral production (see Section 2.2 for further details).[16] Our interviews with the mining industry suggest that ASM continues to provide a similar proportion of these products.

### 3.2.3. Processing Companies

Companies responsible for the mineral processing part of the value chain include local traders or exporters from the country of mineral origin, international concentrate traders, mineral re-processors, smelters and refiners and companies providing storage and transportation.[17] These companies and their relationships vary depending on the mineral and processing infrastructure available in the country of extraction.[17] Depending on the mineral, the companies involved in processing may be the same as those involved in extraction or may involve different specialist companies. For example, those specialising in steel production.[18] State ownership of metal refining has increased, with China accounting for the bulk of this growth.[14]

### 3.2.4. Commodity Traders

There has been a lack of transparency around the role of traders in the minerals sector. Most of the major players are privately held, provide limited information on their activities,[17] and have had limited scrutiny of the governance and sustainability practices.[19] The slow adoption of digital technologies for tracking minerals flows has further limited scrutiny of this part of the mining industry.[20]

Trading companies are influential and important, given their role in ensuring supply, in providing price stability to existing supply chains and in supporting emerging ones. Some have started, albeit slowly, to become more public-facing and collaborative (e.g. working with governments on security of supply).[19]

Major commodities companies are also moving into trading,[19] including some major mining companies.[21] In 2019, it was estimated that there were at least 2,000 companies trading in minerals and metals, of which 56% were owned by other companies and 41% were privately owned. The balance were either listed or state owned.[22]

### 3.2.5. Transport and Logistics Companies

The global mineral market is underpinned by an extensive mineral infrastructure and transport network. This consists of rail, port and shipping services, which provide specialised logistics and transportation for raw and refined minerals from the place of extraction to end user industries.

### 3.2.6. End-User Companies

Whilst not traditionally associated with mining and minerals processing activities, end-user companies are becoming increasingly influential. A number have invested in or acquired mining companies, mines, processing and related infrastructure. For instance, in 2021, battery-cell manufacturing giant Contemporary Amperex Technology Co. Limited (CATL) bought stakes in China's Moly cobalt mine in DRC[23] and acquired lithium mining company Canada's Millennial Lithium Corp.[24] Similarly, Tesla continues to invest in plans to build a lithium refinery on the Texas Gulf Coast of the United States.[25]

End-user companies are also potentially important influences on the mining sector. As customers, they can ask suppliers to conform to particular social or environmental standards, ask for the minerals they use to be sourced only from mines that meet defined social or environmental standards, and for high levels of transparency from the mine through to the point that the mineral is transferred to the end-user.

Different end-users are important for different raw materials. Table 3.1 presents the main end-user industries for different minerals.

*Table 3.1. Mineral Demand by End-User Industry.*

| Mineral Raw Material | Primary End User Industries |
|---|---|
| **Iron ore** | Almost all (98%) iron ore is used for steelmaking[26] and the primary end-user industries for steel are **construction, mechanical equipment** and **automotives**, accounting for 52%, 16% and 12% of global steel use respectively.[27] |
| **Coal (all)** | **Electricity generation** is the primary end-use of coal, accounting for 47% of use in 2022, followed by **steel production** (29% of use in 2022) and **cement production** – which accounted for 15% of global coal use in 2022.[28] |
| **Bauxite/ aluminium** | Most (91%) of bauxite is used for alumina production and in 2023 the main end-user industries of aluminium are: **automotives** (accounting for 30%), **construction** (28%), and **packaging** (16%).[29] |
| **Copper** | Almost half of all copper is used by the **construction** industry.[30] **Electrical and electronic products** accounted for 21% of copper use in 2021, followed closely by **Transportation equipment** (19%).[31] By 2027, the volume of copper required for **EVs** is predicted to more than triple.[32] By 2040, **renewable energy technologies** are predicted to require 40% of the total global share of copper.[30] |
| **Nickel** | Over 66% of global nickel supply is used by the **stainless-steel industry**[33] (in 2022, 29% of stainless steel was used in **mechanical engineering** and 8% in **electrical machinery industry**)[34] while 17% is used in batteries, including for **EVs**.[35] Driven by a rising demand for EVs, nickel demand for batteries is expected to overtake stainless steel demand in the late 2030s.[36] |
| **Rare Earth Elements** | The **permanent magnet** industry accounted for more than 90% of all Total Rare Earth Oxides (TREO) in 2019.[30] The largest end user industries of permanent magnets are the **consumer goods** and **electronics industry** (27% of permanent magnets produced), followed by the **automotive** industry.[37] By 2040 **renewable energy technologies** are predicted to demand 25 - 40% of the total global share of neodymium, a key REE. |
| **Cobalt** | In 2022, 40% of global cobalt was used in **EVs,** followed by **portable electronics** (30%).[30] By 2040 **renewable energy technologies** are predicted to consume 70% of the total global share of cobalt. |
| **Lithium** | In 2023, the **battery manufacturing** industry accounted for 63% of global lithium demand followed by **metallurgy** (27%), primarily for use in the steel industry.[38] By 2040 **renewable energy technologies** are predicted to consume nearly 90% of the total global share of lithium.[30] |
| **Silicon** | Ferrosilicon, primarily used for **steelmaking**, accounts for almost 60% of global silicon demand.[39] Silicon is also used to make silicones which are primarily used in the production of silicone rubber.[40] Highly refined silicon is also widely used for **renewable energy technologies** and infrastructure.[41] |
| **Zinc** | In 2023, the majority of zinc (51%) was used for galvanizing, a process to prevent rusting in the **steel and iron industry.**[42] This process is essential in the production of **renewable energy technologies** such as wind turbines and solar panels.[43] A further 18% was used for **die-casting alloys** which are used in a variety of industries, including **engine components**.[43] There is also growing demand for the use of zinc in the production of zinc-ion **batteries**.[43] |
| **Platinum** | Between 2019 and 2023, 30-44% of global platinum use has been by the **automotive industry**, followed by various industrial purposes, including in the production of **fertilizers, glass and medical components.**[44] |
| **Manganese** | Most (90%) of manganese is used in **steel production** (see iron ore for drivers of steel demand).[45] |
| **Vanadium** | Most (90%) of vanadium demand is driven by **steel production** (see iron ore for drivers of steel demand).[46] Vanadium is also used for energy storage, and this is likely to grow considerably as a result of a transition to **renewable energy technologies.**[46] |
| **Phosphate Rock** | Most (90%) of phosphate rock is used in the production of fertilizer for **agriculture**.[47] |

## 3.2.7. Governments

National, regional and local government have different roles and influences over the mining industry and trade of commodities. These differ between countries. National governments exert authority through a variety of channels including import and export rules, taxation, social and environmental policies and regulations, incentives promoting circular economy and sustainability principles. Local governments are generally responsible for local licenses, and the extent to which social and environmental issues are considered within this, revenue distribution and benefit sharing at a local level, and the selection of preferred mining companies to operate in the jurisdiction.

### Permitting and Licencing

By granting or restricting mining permits, governments can shape mineral supply and the way social and environmental protections are considered. The level of government involved in issuing permits and regulating differs between jurisdictions. For example, in Mexico and Chile mining permits are largely controlled by the national government, whereas in Australia these powers are shared across multiple jurisdictional government bodies.[48]

Issuing permits can be a slow process due to administrative processes and stakeholder consultation. Timeframes vary widely between countries (e.g. seven to ten years in the US, and approximately two years in Australia and Canada).[49] Delays in issuance is a key concern for policymakers in large exporting nations, with the Canadian government, for example, working to shorten the permitting process to help meet future demand.[50] Through licence allocation processes, governments select the companies that can access mining opportunities, and specify the social and environmental safeguards that need to be put in place as part of the mining process.

### Import and Export Rules

While import tariffs, which are subject to WTO regulations have fallen in recent decades, export controls have become increasingly common.[51] In efforts to generate revenue, many countries impose export taxes on raw materials. A 2018 estimate of export taxes on 65 minerals and metals showed the average export tax on raw materials was 9.44% and 7.45% on semi-processed goods.[51] Export controls may also be implemented in response to geopolitical tensions. This is exemplified by China's recent export controls on gallium, germanium and high-grade graphite following the United States' decision to introduce export controls on semi-conductor technology to countries of concern (including China).[52] Controls on the export of raw minerals can substantially increase the costs of purchasing particular minerals and can introduce uncertainty of supply for producers of final-consumption goods (see 'Security of Supply').

One particular issue has been the potential for export taxes to limit a transition towards a circular economy by making it less economical to recover and recycle waste. Whilst slightly out of date, data from 2014 illustrates average export taxes on waste and scrap emanating from all base metals were above 10% and above 15% for waste and scrap from copper, iron and steel, nickel and aluminium, cobalt and titanium.[51]

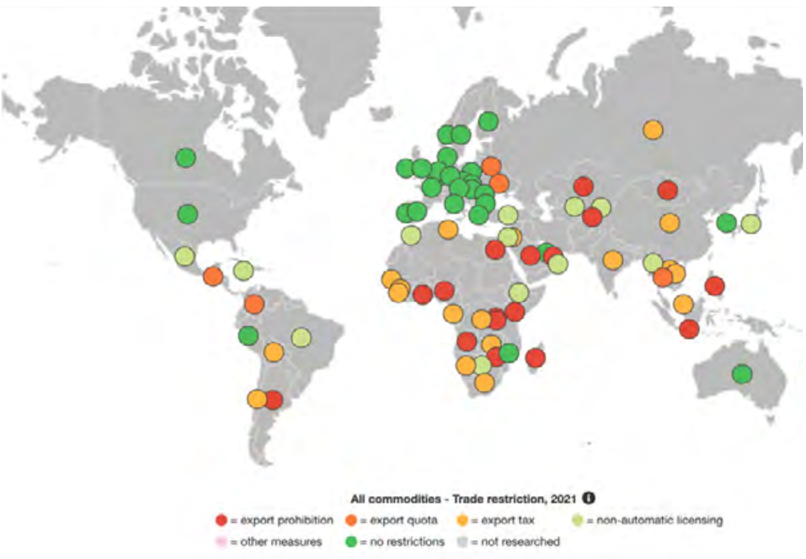


*Figure 3.4. Map of Global Trade Restrictions on Mineral Commodities, 2014. Source: Korinek (2018) Trade restrictions on metals and minerals. Resource Trade.*

Governments play an important role in ensuring that the potential benefits gained from mining activities are captured (through taxation or royalties) and fairly distributed, while companies play a key role in enabling and adhering to responsible tax practices. Challenges, particularly in developing nations, include poorly crafted, outdated taxation regimes which can include outsized fiscal incentives for mining companies[53] and benefits do not flow to those most affected by mining activities.[54] As governments come under increasing pressure to demonstrate positive local impacts, some have begun to decentralise revenue sharing. For example, in the Philippines, 40% of royalties gained from mining activities are kept in the producing province, with 35% of this going directly to local communities.[55] Alternatively, governments may establish foundations, trusts and funds (FTFs) and mandate that mining companies deposit a share of their revenues in these FTFs for the benefit of local stakeholders. Examples include the Ghana Mineral Development Fund and the Mining Social Plan in Senegal.[54]

Tax avoidance, tax base erosion, profit shifting, and illicit financial flows by some mining activities, may limit the extent to which governments can share the benefits of mining. These practices are estimated to result in an annual revenue loss of US$200 billion in developing countries across all sectors.[106]

### 3.2.8. Local Stakeholders

Mining can bring benefits for local stakeholders, for example through employment, boosting local economies, and infrastructure development (see Section 2.1: Mining Contribution). Mining can also have notable negative social and environmental impacts, with local stakeholders particularly affected (see, Chapter 2: Impacts of Mining). In some instances, this has generated tensions and civil unrest, and unaddressed local stakeholder concerns can create pre-production delays in the development of new mines (see Section 1.6.3: Lead Times). In rare cases, local stakeholder action challenging the legality of mining operations has halted production. For example, following protests by environmental campaigners, Indigenous groups and labour activities, Panama's Supreme Court recently ruled that a 20-year concession was unconstitutional, resulting in the closure of the Cobre Panamá open pit copper mine. Another example was Máxima Acuña de Chaupe fighting and winning a legal battle against an international mining company for forced evictions at the Yanacocha gold mine in Peru.[56]

## 3.3. Institutional Investor Levers

**Key Takeaways**

Individually, institutional investors can:

- **Allocate capital** to those mining companies that demonstrate good practice and to those involved in supporting circularity and innovation across the value chain.
- **Collaborating with other finance institutions** including via selection of asset managers, engagement with banks, royalty and streaming companies and insurers;
- Engage in **active stewardship** with companies in **all stages of the mine lifecycle** and **across the value chain**.
- **Engage on policy development** with governments and other stakeholders (e.g. standard setters) to create an enabling environment for a more responsible mining industry.

Collectively, institutional investors can:

- **Develop consolidated investor expectations of the mining industry**, for example through harmonisation of investor expectations in terms of standards, indicators and methodologies. This can establish a common understanding of good practice and drive company progress against this.
- **Facilitate long-term, patient capital across the mining lifecycle** that enables adoption of high standards of social and environmental performance.
- **Reflect investor expectations of high social and environmental performance across the entire value chain** including promoting an integrated approach to circularity.
- **Encourage financial institutions (e.g. banks, lenders) and intermediaries (e.g. stock exchanges) to adopt high ESG standards** in lending and listing requirements.
- **Recognise high standards of performance and positive contributions within ESG frameworks and ratings.**
- **Pool capital** to incentivise industry good practice and to channel capital to activities that reduce mining-related harms and promote positive impacts.

### 3.3.1. Capital Allocation

Institutional investors are likely to be invested in mining companies which are either about to go into operation or are already in production.

Depending on the asset class (public, private, fixed income), investors preferentially allocate capital to companies exhibiting good practice or that have the intention to improve practices. This requires **screening and due diligence** to be conducted on the company and **integration of ESG** issues into the analysis.[57] In the context of allocating capital to mining companies or including a company in the portfolio, this requires investors to understand what good practice and standards for the industry look like.[57]

Investors also have a role in allocating capital to other companies which depend on mining in their supply chains such as automobile, electronics and renewable energy firms. Of particular interest is the potential for these companies to send clear signals (and incentives) to mining companies through developing responsible sourcing policies and through defining social and environmental performance requirements for the minerals and metals procured.

With regards to public equity, when a company does not improve or meet expectations and other escalation activities have been exhausted, investors can also use the **threat of divestment** and **underweighting**.[58] This has been seen more commonly with fossil fuel companies or companies with coal assets in the context of transitioning to a low carbon economy.[58] It is important to acknowledge that, while divestment may seem an easy way of avoiding a particular set of problems, divestment from the mining sector means that investors lose their direct capacity to effect change and may also limit the capital available for investment in critical minerals.

In addition to capital allocation directly into the mining sector, institutional investors can invest in the **circular economy and related infrastructure**, and into **post-mining land restoration and use**. Circularity is not just material efficiencies at the site level but also in eliminating waste, and regenerating nature, as well as innovative business models.

### 3.3.2. Influencing Other Finance Sector Actors

Through their asset manager **selection, appointment and monitoring**, asset owners can require their asset managers to integrate sustainability-related considerations into their investment decisions and engagement with companies. They can also encourage managers to take a longer-term perspective when investing in the mining industry.

Investors can also engage with banks providing project finance to encourage them to adopt and effectively implement higher social and environmental performance standards when lending to mining projects.

**Royalty and streaming companies** could be of increasing relevance. Some of these are listed companies and institutional investors could, therefore, engage with them on their requirements when investing in commodities. However, from our investor survey, there appears to have been relatively little institutional investor engagement with these companies to date.

Investors could engage with **insurance companies** to hold mining companies accountable to ESG considerations as part of their policies and protection against liability. Insurance companies provide a service for some of the harder to reach companies such as those which are privately owned and state-owned companies requiring insurance.

### 3.3.3. Stewardship

There are many opportunities for institutional investors to engage with the mining industry and relevant stakeholders, across **all stages of the mine lifecycle and the value chain**. In these discussions, investors can encourage companies to improve their social and environmental performance.

**Engagement** with investee companies is an obvious mechanism to improve performance. For listed equity investors, engaging with the **majors** provides an opportunity to set expectations of current operations. This is also an opportunity to encourage high expectations of juniors where the majors have **partnerships with junior** mining companies on exploration. Debt investors can also engage with the companies that they have loaned funds to in relation to the conditions that have been set and to identify and manage ESG risks.[59] Engagement can also occur on closure. For example, investors can seek to understand companies' closure plans and how these plans are to be implemented and financed.

For engagement to be effective, investors need to align the requests they are making of companies. It is counterproductive for multiple investors to be engaging with companies but sending different signals. **Voting** on shareholder resolutions is an additional and alternative lever to align and signal a particular request to the company.[60]

Where private equity investors are involved, they – due to their larger stakes – often have more say in the day-to-day and strategic operations of a company. This is particularly relevant for **mid-cap and junior** companies.

In addition to engaging directly with mining companies, investors can engage with the end user industries or **value chain companies** to align on standards required through sourcing practices. It is an opportunity to discuss traceability and transparency in the supply chain, to identify hotspots and to identify where investment is going into companies that do not meet particular social or environmental standards. Consultation for this research process also highlighted the notion of "green premiums" and whether this can be incentivised through demand with an appetite to pay for it. Value chain companies could play a role in this.

### 3.3.4. Policy Engagement

Stewardship is broader than engaging with just companies. Governments are also a key stakeholder to providing the right incentives and policy environment for the mining industry (and related circular economy infrastructure) to achieve positive social and environmental outcomes. **Policy engagement** can influence all stages of the mining lifecycle and the value chain and can be directed at a variety of issues including corruption, accountability and transparency. Policy engagement can occur at different levels:

- Specific jurisdictions and at different scales (local, regional, national) focusing on processes such as permitting, mining codes and implementation.
- At an international level such as through intergovernmental organisations such as the United Nations and through standard-setting bodies.
- At the national level focusing on the conduct of state-owned companies.

Stewardship includes engaging with and/or convening the **broader system or stakeholders** which can effect change in the mining sector. In particular:

- Those organisations or institutions that set standards (see section in standards and disclosure)
- The financial market system, including other financial institutions which finance the mining sector, data or ESG ranking providers, stock exchanges, commodity traders.
- Civil society organisations and local communities, which can provide insights into on-the-ground performance, and whether mining companies follow through on commitments made.
- Academia, which provides scientific evidence of impacts and solutions.

Investors can engage and convene these different stakeholders to align on standards, encourage good practice through the industry and find solutions collectively.

### 3.3.5. Collective Action

#### Alignment and signalling of investor expectations of the mining industry

Alignment and harmonisation of indicators and methodologies will drive better, more consistent, capital allocation decisions, enabling more capital to flow into areas of the mining industry which demonstrate positive impacts. Over 80% of investors in our survey acknowledged that there is a lack of unity (within and amongst) investors with regards to which data points, frameworks and standards should apply to the mining industry. There is no single agreed set of indicators to assess good practice against, meaning that requests from investors to the mining sector can be inconsistent. These inconsistencies are often used by companies as a reason for not changing or for delaying changing their practices or performance.

**Box 13. Key data sources used by investors**

- Ratings, assessments and sector research produced by ESG data and ratings providers.
- Company benchmarks (e.g. World Benchmarking Alliance, BHRRC Transition Minerals Tracker).
- Industry reports (e.g. from investment banks) which consider the financial implications of social and environmental issues for the mining industry.
- Engagement with mining companies.
- Direct investment diligence.
- Sustainability and other reports produced by mining companies.
- Press coverage, e.g. analysis of mining-related controversies.
- Litigation cases.

There is an opportunity for investors to convene and encourage consolidation and harmonisation across standards and requirements. This includes integrating investor expectations in ESG rating agencies' assessments and financial standards such as sustainable bond standards, and developing a common perspective on what constitutes good practice for the industry. This is not a call for a new standard or framework (see Box 10) but rather to encourage the development of a shared understanding of what finance expects from the industry in terms of good practice across different stages of the mine lifecycle, issues and auditing and transparency processes. The actual standards applied can then be chosen by the industry players themselves to meet investor expectations. These common expectations need to be adopted across the finance sector so that they are consistently communicated to the industry, governments and value chain players.

**Box 14. Standards**

**Global Performance Standards:** Globally, and particularly for investors, the most used standards are the IFC performance Standards and the Equator Principles. Other relevant standards include the United Nations Guiding Principles on Business and Human Rights, the OECD Due Diligence Guidance for Responsible Business Conduct and Guidelines for Multinational Enterprises, the Extractive Industries Transparency Initiative (EITI), the International Council on Mining and Metals' (ICMM) Performance Expectations, and Voluntary principles on Human Rights and Security.

**Mining-specific Standards, Assurance and Accreditation:** A range of standards, third-party assurance and accreditation schemes have emerged specifically in relation to mined commodities (e.g. The Initiative for Responsible Mining Assurance (IRMA) launched the Standard for Responsible Mining and certification scheme; Certification of raw materials (CERA), Towards Sustainable Mining (TSM), International Council on Metals & Mining's 10 Mining Principles, the Responsible Minerals Initiative's (RMI) Environmental, Social & Governance (ESG) Standard for Mineral Supply Chains and the Global Industry Standard on Tailings Management (GISTM).

However, the credibility and effectiveness of some standards has been questioned in relation to human rights.[61–63] In the Lead the Charge (2024) assessment (with results that largely align across other independent assessments), IRMA was the strongest performer (scoring 88% against the overall minimum criteria), followed by Responsible Steel (63%) while Aluminium Stewardship Initiative (ASI); Responsible Minerals Initiative (RMI); Copper Mark; Towards Sustainable Mining (TSM) scored between 38 and 59%, while ICMM met 16% of the minimum criteria and the Global Steel Climate Council (GSCC) met only 3%.[61] A 2020 assessment of sustainability reporting in the sector recommends that more coherence and harmonisation across voluntary standard initiatives (VSIs) and encourages governments to encourage or mandate high standards to enhance the reliability and quality of sustainability disclosures.[64]

Consolidation efforts are underway to provide a more harmonized approach. For example, the Consolidated Mining Standard Initiative (CMSI), a collaboration between The Copper Mark, ICMM, Mining Association of Canada (MAC) and World Gold Council (WGC), is working to consolidate their different responsible mining standards into one global standard.[65]

**Responsible Sourcing Standards:** The role of mining-dependent industries in managing environmental and social risks associated with these commodities is increasingly recognised, including calls for more robust due diligence processes across the entire value chain.[37] There is a growing number of initiatives and guidance focused on responsible sourcing, from industry-led frameworks such as the Responsible Minerals Initiative (RMI) and associated Responsible Minerals Assurance Process (RMPA) standards (against which smelters and refiners are assessed), to soft international norms like the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High- Risk Areas which has legal implications for countries adhering to the instrument. However, due to the fragmented nature of mineral value chains, there is currently a limited shared understanding of, or responsibility for, environmental and social risks at mine sites or alignment of expectations across the stakeholders involved.[64]

## The long-term perspective across the mining lifecycle needs to be facilitated

Investor expectations of the industry should reflect the long-term timeframe in which the mine lifecycle spans. This better enables adoption of high standards of social and environmental performance across all stages. Our investor survey provided a mixed picture on whether investment time horizons (which can be very short-term) have an impact on company performance in managing ESG impacts.

What is clear is that – despite the growth in the number of investors committed to responsible investment - many investors focus most of their attention on financial metrics and pay relatively little attention to ESG issues.[67] Our discussions with mining companies suggested that they are not seeing ESG topics being raised as a priority at AGMs or in shareholder meetings (in particular in markets such as the US and Asia).

## Investor expectations need to be reflected across the entire value chain and across all actors

Value chain companies have a role in creating demands of the mining industry. This is another opportunity to align and implement investor expectations down the value chain. It requires investors to set expectations and require downstream companies to uphold traceability and minimum standards across their supply chains.

In addition to expectations of the mining industry, value chain companies are also an opportunity for investors to facilitate the wider innovation and application of circularity principles.

## Exchanges need to set ESG reporting requirements

Many of the major stock exchanges do not have mining-specific sustainability or ESG disclosure requirements as part of the listing requirements. Two thirds of the investor respondents to our survey agreed that stock exchanges should require minimum ESG standards in listing requirements.

According to the Sustainable Stock Exchanges Initiative[68] 39 out of 122 stock exchanges have ESG reporting requirements as part of listing rules. However, these 39 exchanges do not include ASX, LSEG, NASDAQ, NYSE, TSX which is where many mining companies, royalty and streaming companies and banks are listed. Some of these exchanges do publish sustainability-related reporting guidance (e.g. LSEG which calls for companies to disclose according to ISSB) but this guidance is not mandatory. Neither ASX nor TSX - the key exchanges for juniors listing during the exploration stage – have mandatory ESG listing criteria.

It is worth noting that the London Metals Exchange – a commodity exchange rather than a stock exchange – does have responsible sourcing rules aligned with the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High Risk Areas.[69]

## Revamping taxonomies and rating agencies

Greater regulatory, reporting and disclosure requirements are driving the integration of ESG issues into investment decision-making. However, in our survey, some investors noted that absolute exclusion criteria are more widely used than performance-based ESG criteria in decision-making.

One issue – given that the industry needs capital and that it needs investors committed to dialogue and engagement on sustainability-related issues – is that many sustainable finance taxonomies do not consider mining as meeting the threshold for 'green'. Nor do these taxonomies recognise mining's role in the supply chain of "green sectors" such as renewable energy technology. Perhaps ironically, the end user industries of mined products are considered 'green', but mining is not. A practical consequence is that institutional investors concerned about sustainability could find that they are encouraged to invest in downstream industries rather than into mining itself.

Benchmarks and ESG rating agencies often rank or score mining poorly (e.g. see the S&P ESG Industry Report Card for Metals and Mining).[70] This further disincentivises investors from investing in the mining industry.[70] Through the interview process for this research, it was reported that banks or investors who finance or invest in the mining industry are also penalised (or rated as poor) by many ESG ratings, which creates reputational risk. The investor survey revealed that some asset managers are required to respond to ESG ratings agencies by asset owners, who dictate score thresholds to prevent investments in low rated companies. This can lead to a purchase embargo on mining companies who fail to meet the ESG criteria.

To incentivise capital towards the right type of mining, ESG frameworks and ratings need to recognise the role of mining and acknowledge individual companies exhibiting good practice and those showing signs of intention to improve – as opposed to downgrading the overall industry. To do this:

- Taxonomies should recognise mining as part of the supply chains of other "green" industries and fundamental to meeting future societal goals and the transition to a low carbon economy.
- Investors, rating agencies and taxonomies should recognise the positive social and environmental contributions of individual mining companies and of the sector as a whole.
- Financial institutions which invest in the mining sector and are applying good practice expectations of the industry should not be penalised.
- Rating methodologies should be aligned with investor expectations and industry standards to help investors assess what is poor practice (beneath the threshold), minimum practice and leading practice, providing a spectrum for investors to assess companies against.

## Establish an initiative to explore financing mechanisms

A pool of capital that could incentivise good practices by the mining industry and channel capital to those activities which either reduce negative impacts or create opportunities to meet the vision of the Commission could be explored. Over 50% of investors responding to the survey agreed that there are significant opportunities in the circular economy and related infrastructure, and post-mining land restoration use.

An initiative would explore different outcomes and mechanisms. For example – to illustrate the breadth of options available – this could include:

- **Encouraging capital to be directed to best-in-class companies based on their social and environmental performance.** This would help channel capital towards companies that exhibit best practice or which are transitioning/improving towards good practice. This would provide a clear incentive for companies to improve their practices and performance.
- **Financing the restoration of closed mine sites, or the development of alternative economic activities.**
- **Financing research, development and innovation into circular economy infrastructure.**

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# 4. Role of Institutional Investors in Realising a Socially and Environmentally Responsible Mining Industry

Drawing on the preceding research, this chapter highlights key areas where collective investor action can realise a more socially and environmentally responsible mining sector. It introduces a set of strategic objectives and actions that the Global Investor Commission on Mining 2030 will take forward into a second phase of planning. This direction of travel is informed by the key findings of the research and was developed in collaboration with Commission members.

Commission members analysed the direct causes and contributing factors that resulted in the impacts identified in Chapter 2. Based on this analysis, the Commission then **identified common, high-level underlying issues which, if addressed, would in turn contribute to avoiding and mitigating several (if not all) of the negative impacts and to maximising the sustainable, long-term positive impacts of the sector.** Following discussion with Commission members and investors to further refine these issues, these were filtered to identify those most strategic to the investor coalition, i.e. those issues where investors can exert the most impact and are not already active.

This process identified the following high-level, strategic issues:

## 4.1. Ensuring Effective Corporate Governance

Effective oversight and management by the company of its social and environmental impacts (broadly referred to as corporate governance) is key to mitigating harms by individual companies to the environment and society. In turn, this can shape the sector's collective contribution to conflict and social justice. Through effective identification, assessment, management, monitoring, review and corrective action, companies can do much to avoid and mitigate the negative impacts of their mining activities. In addition, they can amplify contributions to long term, sustainable benefits of mining. Ensuring that companies do so and encouraging these actions to be taken by all companies and not only industry leaders on sustainability, is a key area for collective investor action to help achieve a more responsible sector.

As such, the Commission will seek to: **Improve company social and environmental performance by developing investor expectations aligned with global and industry standards.**

## 4.2. Enabling Integrated Action Across the Value Chain

Mineral value chains are complex and global and are increasingly exposed to challenges. These include issues arising from geopolitical tensions - including protectionist actions such as export restrictions, skills shortages, and anticipated growth in the gaps between supply and demand (Section 4.6). Overcoming these challenges and enhancing supply chain resilience requires a systematic and holistic value chain approach. This can include enabling and scaling innovations, the application of circularity principles, and greater transparency. The mineral value chain is currently typically managed within organisational silos rather than as an integrated process, with limited coordination and data exchange in real-time. A more unified value chain has the potential to improve management of risks, unlock greater value, and manage market volatility. Achieving this requires deliberate, cross-sector and public-private collaboration and partnership, with investments in sustainable and scalable changes to business models.

Moreover, numerous industries are reliant on mined commodities, including many that are considered sustainable (e.g. renewable energy) and essential to human development and well-being (e.g. food production, energy generation, electronics, medical equipment). Although these value chain industries are reliant on mined commodities, the risks resulting from social and environmental impacts of mining are largely borne by the mining sector, with limited integrated action with and by mining-dependent industry actors to mitigate risks associated with mining.

As such, the Commission will seek to: **Improve company social and environmental performance, including wider application of circularity principles, by aligning value chain industries with Investor Expectations**

## 4.3. Facilitating Effective State Governance, Regulation and Enforcement

Effective state governance is critical to realising a more socially and environmentally responsible mining sector, both in terms or reducing impacts and in enabling social benefits. As such, ensuring that existing regulatory frameworks are fit for purpose and effectively applied, including comprehensive and robust social and environmental safeguards, is a priority.

In framing policies and strategies for the approval of mining projects, governments should, at the outset, integrate a review of environmental and social impacts alongside economic factors, based on a clear understanding of the potential positive and negative impacts. Policy processes should be designed to enable regulators and other stakeholders to participate in the identification and review of predicted impacts and mitigation measures before a mining proposal is approved, as well as support transitions that address social and environmental impacts throughout the mine lifecycle and following mine closure.

As such, the Commission will seek to: **Improve company social and environmental performance by strengthening regulation and institutional frameworks to reinforce Investor Expectations**.

## 4.4. Promoting Fairness and Transparency in Decision-making and Distribution of Benefits and Harms

Ensuring good process regarding consultation, effective participation, FPIC (with Indigenous Peoples), grievance mechanisms, and remedy is a foundation of addressing harms and co-creating adequate compensation and benefit sharing. This is key to generating long-term, sustainable benefits.

Currently there is a lack of inclusion of and respect for, voices of affected stakeholders and rightsholders in decision-making. There are opportunities to build their capacity to participate fully in these processes and enhance transparency around the potential impacts of mining activities, benefits distribution, and the equity of benefit sharing. Both excluding affected stakeholders and rightsholders effectively in decision-making processes and the inequitable distribution of harms and benefits from mining can generate or exacerbate disputes and conflict (Section 2.3.4. Competition over Resources).

As such, the Commission will seek to: **Create fair and sustained benefits at local and national levels through improved equity and transparency in decision-making and benefit distribution.**

## 4.5. Ensuring Responsible Mining in Conflict Affected and High Risk Areas

Improving company practices (Objective 1) and state regulation and enforcement (Objective 2) will help to avoid and reduce harms that can create or exacerbate mining-related conflicts. A focus on improving process and transparency in benefit distribution will contribute to more equitable distribution of harms and benefits and promote long term, sustained benefits from mining activities (Objective 4). This will, in turn, help to reduce drivers of mining-related conflict tied to lack of effective process, inclusion and respect for voices of affected stakeholders and rightsholders, and inequitable distribution of burdens and benefits. A number of minerals are sourced from conflict areas and reserves for a number of transition minerals are located in fragile states, while conflict is also increasing globally. As such, the Commission recognises the need for an additional strategic focus on ensuring responsible mining in conflict-affected areas. This will involve targeting conflict-affected areas and providing additional guidance on application in conflict-affected areas in delivery of Objectives 1-4 and may also involve developing additional strategic action specifically addressing responsible mining in conflict-affected areas.

As such, the Commission will seek to: **Reduce mining as a driver of conflict through improved identification and management of risks linked to mining-related impacts and revenues.**

## 4.6. Creating Positive Legacy Impacts

Although the exact figure and locations are not known, there are estimated to be millions of historic legacy mining sites globally, many with enduring negative impacts on people and the environment. Moreover, thousands of currently operational mines are expected to close in the next 10 to 25 years. It is therefore necessary to both address existing historic legacy issues, as well as to avoid and reduce these issues arising in the future by ensuring good planning and process for mine closure and post-closure transitions. Improving company practices and state regulation and enforcement will contribute to improved planning and practice for mine closure, though there may need to be additional focus on institutional investor influence on this stage of the lifecycle in delivery of the objectives. However, historic legacies will need to be addressed by the Commission separately through additional, targeted strategic actions.

As such, the Commission will seek to: **Drive safe and responsible mine closure and the creation of positive legacies for existing mining operations and address historic legacies of mining.**


*Figure 4.1. Strategic Approach of the Global Investor Commission on Mining 2030*

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