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Environmental and Social Sustainability All Along the Supply Chain

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5. Environmental and Social Sustainability All Along the Supply Chain

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Summary:

Mineral industries are often perceived as polluting and socially disruptive. However, increasing demand for minerals essential to the energy transition means we will need to rely on mining and mineral industries more than ever in the future. Current efforts for strengthened sustainability along mineral supply chains are abundant: numerous voluntary industry standards exist, as well as efforts to strengthen due diligence and circularity at all levels of the supply chain. However, further international collaboration is needed to harmonize existing standards, ensure the economic viability of green mineral operations, develop a global framework for circularity and strengthen capacity building.

Sustainability is defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs". Ensuring this principle is upheld throughout mineral supply chains entails **implementing practices that minimize environmental degradation and promote social responsibility**. This includes responsibly sourcing raw materials, reducing energy consumption and emissions during extraction, processing and manufacturing, implementing fair labor practices, fostering community engagement and empowerment, and promoting transparency and accountability in governance. Additionally, it involves investing in research and innovation to develop more efficient and environmentally friendly technologies, as well as advocating for policies that support sustainable resource management and equitable distribution of benefits.

Although the urgency of addressing climate change could pressure stakeholders to disregard other aspects of environmental, social and governance (ESG) performance, these are crucial in enabling the smooth concretization of mining and industrial projects. **Ignoring local concerns and negative environmental impacts could fuel social resistance to a specific project and to mineral operations more widely.**

5.1. Evolving Scope of Sustainability Expectations

Although sustainability across the value chain is the intention, focus has mostly been at the upstream (extraction) level, with comparatively less definition of expectations and understanding of risks at midstream (processing) and downstream (manufacturing) levels. This can be linked to the visibility of mining operations, inherently tied to resource location, and to the scale of environmental and social fails in the sector, which concentrate public attention.

However, as the strategic value of mineral processing emerges in the context of the criticality agenda – the capacity to transform raw materials into valuable mineral products is the linchpin of mineral value chains and a key stake in geostrategic tensions – its environmental and social performance and responsible governance are attracting more consideration. There are also civil society movements advocating for drastic changes in industrial practices, from reduction of mineral consumption or 'material footprint', to designing for circularity and increasing resource efficiency across manufacturing, and hence redefining the scope of sustainability expectations [1].

As such, to design effective governance frameworks and improve stakeholder trust in the sector, it is essential to acknowledge the reality of the adverse impacts of mining that have shaped its poor perception [2].

Social Impacts of Mining

Because "mining" encompasses under a single word realities from artisanal diggings to "mega-pits" across all geographies and governance contexts, its social impacts reflect this diversity of circumstances and can include:

- **Poor working conditions**: Mining is frequently associated with health and safety hazards and human rights violations. Examples include exposure to hazardous substances and unsafe mine environments leading to work-related accidents and fatalities, inadequate wages, forced labor, as well as child labor.

- **Conflict**: Mining can lead to expropriation of land, displacement of local communities and/or temporary migration of workers into mining areas. The disruption of livelihoods, inadequate access to basic facilities, and the perceptions of increased inequalities from mining "boom and bust" cycles can lead to increased tensions and generate social conflict. It has been found that more than one-third of transition mineral projects are located on or near indigenous or peasant land facing a co-occurrence of water risk, conflict and food insecurity [3].

- **Corruption**: Given the close interaction between private actors and public sector regulators, governance of mining operations, mineral products and the revenue they generate for the State has proven a challenge. Corruption may manifest in bribery to obtain permits and licenses, opaque ownership structures, or misappropriation of government revenues or funds earmarked for local communities.

These phenomena are particularly rampant in areas with high concentrations of Artisanal and Small-scale Mining (ASM). ASM, as distinguished from large-scale or industrial mining, is characterized by its low levels of capital investment, high degree of labor intensity, as well as poor occupational health, safety and environmental standards. Approximately 45 million people are engaged in ASM, producing significant amounts of minerals, including an estimated 12-24% of the global cobalt supply [4]. In addition to governments facing challenges in regulating this sector, ASM miners also largely do not have the means (in terms of skills or capital) to comply with regulation which was not designed for them. This problem is further exacerbated by overlaps with industrial mining operations, causing tensions or providing opportunities to bring illegal materials into global value chains by blending production from different sources.

However, it is worth noting that mining, when correctly regulated, also contributes to many positive social impacts, such as local employment, both direct and indirect, poverty alleviation, and economic development. Government revenues can be invested in infrastructure and human capital development, spurring sustainable, long-time growth. Chile, for example, the most mineral-dependent country in South America, has seen rapid economic growth and Human Development Index (HDI) improvement, with the highest HDI score in the region in 2022 [5].

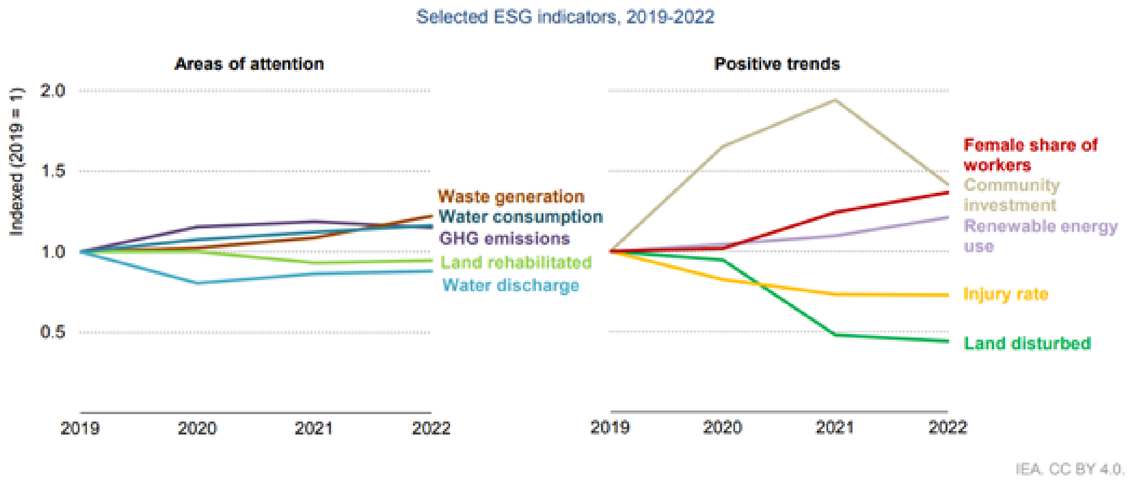
Environmental Impacts of Mining

While critical minerals are key for the energy transition, they are also associated with negative environmental impacts that should be mitigated in order to ensure a sustainable and fair energy transition. These can include:

- **Biodiversity loss**: Mining often brings major land use change and damage to natural habitats and ecosystems. This can include deforestation for the construction of large open-pit mines, and soil contamination resulting from inadequate waste management practices. These impacts exacerbate the loss of flora and fauna within affected areas.
- **Water depletion and pollution**: Mining is highly water intensive, with water as a major input in extraction and processing activities. Yet mining of certain minerals is currently concentrated in high water-stress areas, with over 50% of lithium and copper production in areas in north-western Australia and northern Chile, for example [6]. Acid mine drainage (formation of acidic water from contact with sulfur-bearing minerals), tailing (waste) disposal, wastewater discharge, and mine dewatering (removal of groundwater to maintain access to the mine) can also cause contamination of water bodies and aggravate existing water stress.
- **Air pollution and GHG emissions**: Drilling, excavation, blasting, ore crushing, smelting and refining produce fumes and particulate matter, and hence air pollution threatening the environment and human health. Due to the industry's reliance on heavy equipment and fossil fuels, mineral processing is also highly energy and emissions intensive, with fuel combustion producing gaseous emissions such as sulfur, nitrogen and carbon oxides that contribute to climate change. It has been estimated that primary mineral and metal production was associated with 10% of the total global energy-related GHG emissions in 2018.

In recent years, the mining sector has responded to growing concerns and calls from civil society for more environmentally sustainable practices. Major mining companies such as BHP, Glencore, Rio Tinto and Vale have announced commitments to achieve net zero emissions by 2050 and improved public disclosure of ESG information. In an analysis of 25 major mining companies, the IEA found that almost all reported their total energy consumption and scope 1 and 2 GHG emissions. However, the reporting of other indicators is much less common – only 10 reported on land area disturbed and rehabilitated, for example [7]. Similarly, the Responsible Mining Index assessed the ESG policies and practices of 40 of the largest global mining companies and found an overall average environmental responsibility performance of only 29%. Furthermore, while companies may track and disclose ESG data such as biodiversity protection, tailing risk management, water consumption, water quality and GHG emissions; few conducted reviews or audits on the effectiveness of their management measures, and even fewer could provide evidence of having taken any action in response [8].

Therefore, while the increased reporting and transparency is encouraging, tangible progress is still lacking. The IEA report showed that, between 2019 and 2022, water use had in fact increased by 25%, while mining waste generation increased by 20%, and GHG emissions had stayed relatively constant [9].



Source: "Global Critical Minerals Outlook 2024" by the International Energy Agency (2024))

5.2. Efforts for Sustainability: Responsible Mining Standards, Vertical Integration and Circularity

Surveying the Current State of Responsible Mining Standards

Multiple international standards exist on responsible mining and processing, aligning with global frameworks including the OECD Due Diligence Guidance for Responsible Business Conduct, UN Guiding Principles on Business and Human Rights and the sustainable mining standards developed by the International Labor Organization.

In addition to binding policies, upwards of 400 voluntary initiatives and standards across all sectors are also available [10]. Key standards include the Copper Mark Criteria for Responsible Production, Extractive Industries Transparency Initiative (EITI) Standard, International Council on Mining and Metals (ICMM) Mining Principles, Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF) Mining Policy Framework and Initiative for Responsible Mining Assurance (IRMA) Standard for Responsible Mining. While not specific to the mining sector, the International Finance Corporation (IFC) Performance Standards are also widely adopted.

In terms of the environment, these standards largely require members to avoid operating in World Heritage sites and legally protected areas, and to commit to the no net loss principle. The IRMA and Copper Mark standards cite the UN Convention on Biological Diversity, the World Heritage Convention and the Ramsar Convention on Wetlands; while the TSM Standard requires that companies report on their water stewardship. The ICMM Principles call for members to achieve net zero scope 1 and 2 emissions by 2050. The IGF Framework recommends that governments adopt policies on biodiversity management, water management and GHG emissions reduction.

Most standards also address human rights, health and safety standards and community engagement. The EITI Standard in particular aims to promote transparency, public and corporate governance, and accountability, requiring disclosure of information such as company expenditure, company payments, and government revenue allocations.

Where gaps in formal regulation and governance exist, voluntary standards help to play an important role. In comparison to traditional "command-and-control" regulations that may be perceived as expensive to comply with and may create legal liabilities for companies [11], voluntary standards are more accessible and flexible, and can be tailored to the company's needs, the local conditions, and stakeholder expectations. They can be an opportunity to transition into introducing legal requirements and are therefore an important starting point. However, voluntary standards are also subject to their own limitations:

- Existing voluntary standards are **not consistent in their diverse commitments**, as well as their level of detail, stringency, and measurement methodologies, **making measuring the impact and effectiveness of voluntary standards challenging**. For example, the TSM and IRMA standards require the establishment and continuous monitoring of site-specific and catchment-level water balances as well as the implementation of environmental protection and mitigation measures, whereas the Copper Mark primarily targets mitigation strategies, and the ICMM encourages their adoption without making them compulsory. Impact assessments are also largely anecdotal or in the form of self-assessments [12]. Data may be provided at a granular level across several categories and years, or only for certain sites, or even only at an aggregate, company-wide level, combining data from different minerals and different sites. Baseline data may or may not be available. Even if standards are adopted, the risk of a lack of proper compliance, and hence a "greenwashing" or "label-shopping" exercise, remains.
- While many standards cross-recognize other standards, **transparency is limited, and integration and alignment efforts with international due diligence instruments vary** [13]. These inconsistencies and lack of harmonization can result in increased costs and confusion for companies, uneven implementation and unpredictable environmental outcomes. Governments, investors, consumers, and other stakeholders may therefore find it more difficult to assess environmental sustainability using such standards.

The Rise of Vertical Integration in the Mining Value Chain: Enhanced Due Diligence?

Amid sustainability concerns, the need for due diligence, and increasing supply risk, some downstream companies are pursuing vertical integration of some of their mineral supply. Electric vehicle manufacturers like Tesla, Toyota, and Volkswagen are securing transition mineral supplies through partnerships with mining firms, while giants such as Rio Tinto, BHP, and Vale are investing in downstream operations like smelting and manufacturing. Joint ventures, like Rio Tinto and Alcoa's integrated aluminum operations, are on the rise [14]. Vertical integration not only ensures a stable resource supply and reduces price volatility, but can also **enhance sustainability by allowing stricter environmental standards and practices throughout the value chain**. By controlling multiple stages, companies can optimize processes, reduce waste, and improve energy efficiency. For instance, Nouveau Monde Graphite, a Canadian company, aims to minimize its carbon footprint by integrating hydroelectric-powered mining and processing operations [15].

Vertical integration provides companies with **greater transparency and traceability throughout a supply chain**. This visibility allows them to ensure responsible sourcing, monitor environmental impacts, and implement sustainable practices from the sourcing of raw materials to the delivery of final products. By streamlining operations and logistics through vertical integration, companies can optimize resource utilization, reduce transportation needs, and minimize associated emissions and environmental impacts.

However, vertical integration has also proven very effective in increasing opacity and transfer pricing, negatively impacting prices, as well as in defining monopolies or oligopolies that can hinder companies' ability to adopt more sustainable alternatives, like battery chemistry substitutes, or increase supply constraints and criticality. Moreover, vertical integration does not directly mitigate a wide range of sustainability risks but rather offers companies avenues to enhance environmental sustainability and supply chain transparency should they choose to do so – corporate leadership, regulatory constraints and stakeholder scrutiny at key supply chain levels remain essential to drive sustainable choices.

Challenges and Opportunities in Advancing Circularity in Mining Supply Chains

A key strategy for reducing environmental impacts in mining supply chains is increased circularity. **Process circularity** refers to the reduction of emissions and mining wastes, whereas **product circularity** refers to the repair, reuse and recycling of products to extend product lifetimes and finally recover secondary material. Secondary raw materials are typically less water, energy and emissions intensive compared to primary raw materials [16], and recovery rates of more than 90% for copper, cobalt and nickel, and 80% for lithium, are technologically feasible [17].

Mineral	Recovery Rate (Current)	Recovery Rate (Best Available Technology)	Recovery Rate (Circular Economy)
Cobalt	32-74%	96-99%	95%
Copper	45-60%	100%	95%
Dysprosium	>1%	60%	60%
Lithium	>1%	80%	80%
Manganese	53%	95%	95%
Neodymium	>1%	95-99%	95%
Nickel	57%	90%	90%
Platinum	60-70%	95-99%	95%

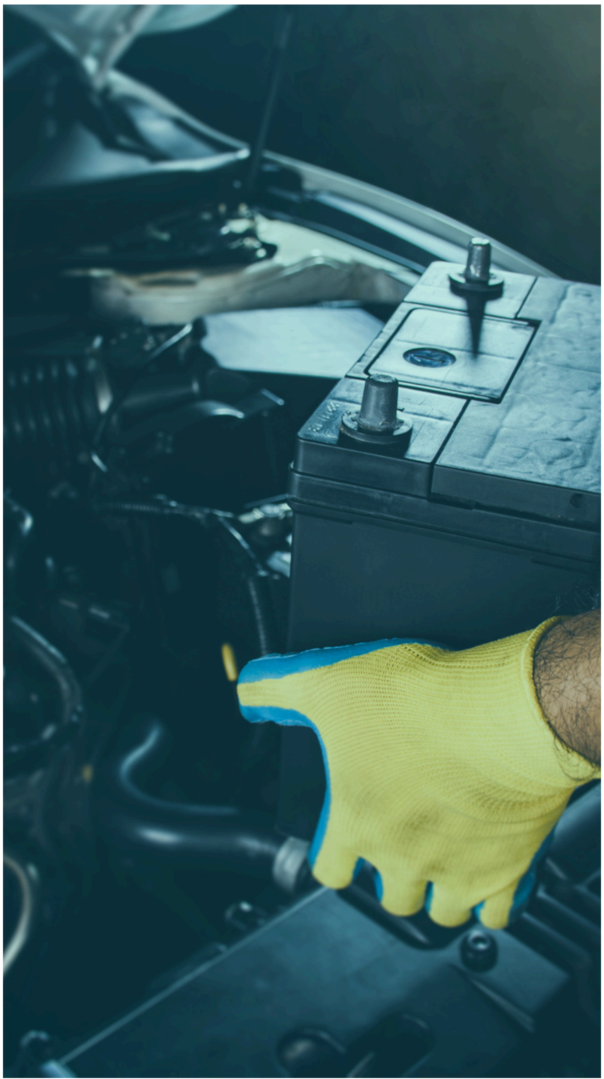
Source: "Critical Minerals and the Green Energy Transition" by the Environmental Justice Foundation (2024), adapted from Simas et al. (2020)

Making productive use of mining waste could serve as a cornerstone of such a circular economy strategy. An estimated 100 billion tons of solid waste is generated from the primary production of minerals and metals, with waste produced ranging from several times the mass of elements extracted, such as for iron and aluminum ore, up to millions of times for elements such as gold ore [18]. Transition minerals have successfully been recovered from mining waste, with cobalt and copper recovered using flotation techniques, and iron, manganese, titanium and chromium using magnetic separation. However, the economic feasibility of these processes still presents a challenge for their widespread deployment.

With regards to product recycling, some regulatory efforts have been made at the regional level. The European Union (EU) has put forth a range of legislation such as the Waste Electrical and Electronic Equipment Directive, the End-of-Life Vehicles Directive and the EU Battery Regulation, that set targets for collection, recycling and recovery of the relevant products. The proposed Ecodesign for Sustainable Products Regulation will also see ecodesign requirements for specific product groups to improve their circularity and environmental sustainability, and the new Digital Product Passport will allow for the provision of information such as the recycled content of a product, and its durability and reparability.

Despite these technical advancements and regulatory efforts, however, actual recycling rates remain low – of the 34 critical raw materials identified in the European Commission's 2023 criticality report, only 10 had 10% or more of their EU demand met through secondary raw materials [19]. Key challenges to recycling include **low waste collection rates, contamination and mixing of different grades of scrap, inconvenient product design, lack of information on product composition, high cost of recycling, inadequate waste management regulations, and poor monitoring and enforcement systems.**

Moving from the traditional linear production model to a circular one would therefore necessitate systemic changes across the entire value chain, requiring **significant investment and political pressure**. In some cases, trade-offs may even need to be made between improving technology, cost and material efficiency, and facilitating recycling – for example, efforts to improve battery energy density and packaging may hinder ease of disassembly and recycling. Finally, it is noted that recycling can only be scaled up as transition mineral products reach end-of-life, such that many secondary minerals will not be available for decades. Hence, the level of circularity of the mineral supply chain is still limited, especially in the near term.



5.3. Envisioning the Future: Strengthened International Collaboration for Sustainable Mineral Supply Chains

Global Efforts to Harmonize Responsible Standards

As called for in the Declaration on Promoting and Enabling Responsible Business Conduct in the Global Economy at the 2023 OECD Ministerial Meeting on Responsible Business Conduct, there is the need for **the "coherence, alignment, and harmonization of responsible business conduct standards"**. This would encourage greater transparency and consistency across different standards, minimize duplication, improve their legitimacy among different stakeholders, and hence improve their efficiency.

Efforts have been made to consolidate diverse standards into one "gold standard", notably by ICMM which has launched the Principles for Responsible Investment as well as the Global Industry Standard on Tailings Management with the UN in the wake of the tailings facility failure in Brumadinho, Brazil, that resulted in the deaths of at least 259 people. The Copper Mark, Mining Association of Canada, ICMM and the World Gold Council are also working towards consolidating their individual voluntary responsible mining and metals standards into a single global responsible mining standard, and multi-stakeholder governance structure [20].

Another notable effort aiming to establish a comprehensive framework for evaluating standards in this domain is the work carried out by the International Social and Environmental Accreditation and Labelling (ISEAL) Alliance. They have defined Credibility Principles for sustainability standards and certification schemes, as well as a Code of Good Practice for Sustainability Systems. Sustainability systems and accreditation bodies that meet eligibility criteria, commit to continuous improvement and adhere to the ISEAL Code of Good Practice are recognized as ISEAL Code Compliant, and this has become a quality governance benchmark for standards.

Furthermore, the OECD has published alignment assessments with the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas for 5 industry programs, and this methodology could also be applied to assess other standards. Other potential references for evaluating sustainability standards could include the UNEP environmental, social and sustainability framework, the UN Guiding Principles on Business and Human Rights, and the EU principles for sustainable raw materials.

Finally, to ensure accountability and diverse voices, **multi-stakeholder collaboration** is key. Given that most standards are industry-initiated, such as through national associations or global collaborations of mining companies [21], there is a need for non-industry stakeholders such as governments and civil society to participate in the conversation. One good example is IRMA, whose board is governed by representatives from mining companies, processing companies, non-governmental organizations, affected communities, organized labor, and investment and finance. International efforts in harmonizing standards must therefore take into account a similar range of voices and views to inform decisions.

Global Efforts to Establish a Viable Market for Sustainably Sourced Minerals

It is difficult to assess if **the costs of complying with more stringent environmental requirements, integrated into a "green**

premium" for minerals, would find a market and incentivize more sustainable production.

Different minerals will see different demand and supply outlooks that will affect the viability of a green market. For example, McKinsey has argued that since copper contributes a small share of overall cost and Scope 3 emissions for most end products, interest in low-CO2 copper will be limited [22]. Similarly, in response to calls for the introduction of a green premium for nickel, the London Metal Exchange (LME) has said that it believes that the market for green nickel is "not yet large enough" and would not attract sufficient stocks and trading volumes.

On the flip side, in 2020, the LME had announced plans to launch a platform for trading low-carbon aluminum, but was met with opposition from industry players that cited concerns about the lack of standardization in calculations of carbon content. However, the recent alignment of LME requirements with the European Carbon Border Adjustment Mechanism to compel aluminum producers to submit Scope 1 and 2 emissions data, as well as the roll out of the LME passport, a store of electronic certificates of analysis and sustainability data, may suggest a shift towards improved reporting that could form the basis of future green markets.

As such, there are still demand- and supply-side challenges in building bifurcated markets for responsible and sustainable minerals, and it is uncertain whether producers can count on a green premium to fund sustainability measures.

Global Efforts to Strengthen Circularity

Although some regions, such as the EU, have established regulatory frameworks for battery recycling, **regulatory safeguards and enforcement are inadequate in many parts of the world. The development of international common standards and guidelines** for the sustainable and responsible recycling of minerals used in batteries and renewable energy technologies is crucial to unlocking the full potential of mineral recycling in supporting the clean energy transition. This would **necessitate a platform or forum for coordinated efforts** involving governments, industry players, and relevant stakeholders.

Relevant areas of work could include:

- **Standardized Design of Designated Products**: Incentivizing product designs with greater material efficiency and durability, that are more easily disassembled and recycled. The EU ecodesign regulation is a promising policy that can be more widely applied globally, such that products containing recoverable transition minerals are well-labelled for the benefit of both consumers and waste processors.

- **Standardized Product "Passports"**: Digital product passports can be used to "electronically register, process and share product-related information" such as **product composition, material origins, and carbon footprint** [23], and hence increase transparency and traceability along the value chain, and enable consumers and policymakers access to sustainability information. As a means for companies to monitor, report and compare against sustainability indicators, the product passport can encourage greater sustainability. Furthermore, by including information on product repair, disassembly, recycling and disposal, product passports can also be used to support circular economy strategies, as targeted by the EU Battery Passport. Product passport initiatives can already be found across a range of sectors, including construction, consumer goods, electronics and textiles, but have largely been a result of private sector efforts, and hence tailored to the specific sector or company [24]. A more international, standardized product passport for minerals could therefore be considered, allowing for interoperability while retaining set levels of stringency and legitimacy.

- **Studying the Use of New Technology for Traceability**: to improve transparency and traceability, the implementation of new technologies such as **blockchain** technology can be considered. Blockchain is a digital, decentralized ledger that stores data transactions in blocks that are chronologically linked in a chain. Each transaction is validated by the network and cannot be forged, and is also unmodifiable and therefore immutable. Furthermore, the ledger is accessible by all the parties in the network [25]. As a result, these tamper-proof, distributed data records can enable trustworthy and comprehensive reporting on products and their supply chain, and the tracking and tracing back to their basic raw material components [26]. This can not only encourage more responsible and sustainable production, but also furnish useful information that can aid in the reuse and recycling of products. One example of the application of blockchain in the mining industry is the **Everledger project** under the Australian Blockchain Pilot Grants program, that aimed to build supply chain integrity and contribute to the Critical Minerals National Ethical Certification Scheme.

Global Efforts to Assist Developing Countries in Sustainable Goals

Finally, as mentioned previously, **developing countries generally do not have sufficient human and financial capital to implement sustainability standards**. They are challenged with poorer transparency, accountability and reporting standards, and limited data, knowledge and institutional capacities. Given the complex geopolitical landscape inherent to mining, and to avoid the subcontracting or offshoring of unsustainable mining practices, it is necessary to ensure that sustainability policies and efforts are uniformly applied for both developed and developing countries, as well as both large-scale and small-scale mining.

Financial and technical assistance should therefore be provided by international bodies to meet these gaps, and enable the R&D and regulatory efforts discussed earlier. Technical assistance should also be provided to encourage compliance, transparency, as well as public, user-friendly reporting, such that information is available especially to the local communities that are directly impacted by mining activities. Given the diversity within the mining sector on both the global and national levels, there is also a need for context-specific governance solutions, and this will only be possible through multilateral conversations and partnerships between countries [see *paper on Equitable Opportunities for Resource-Rich Countries*].

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