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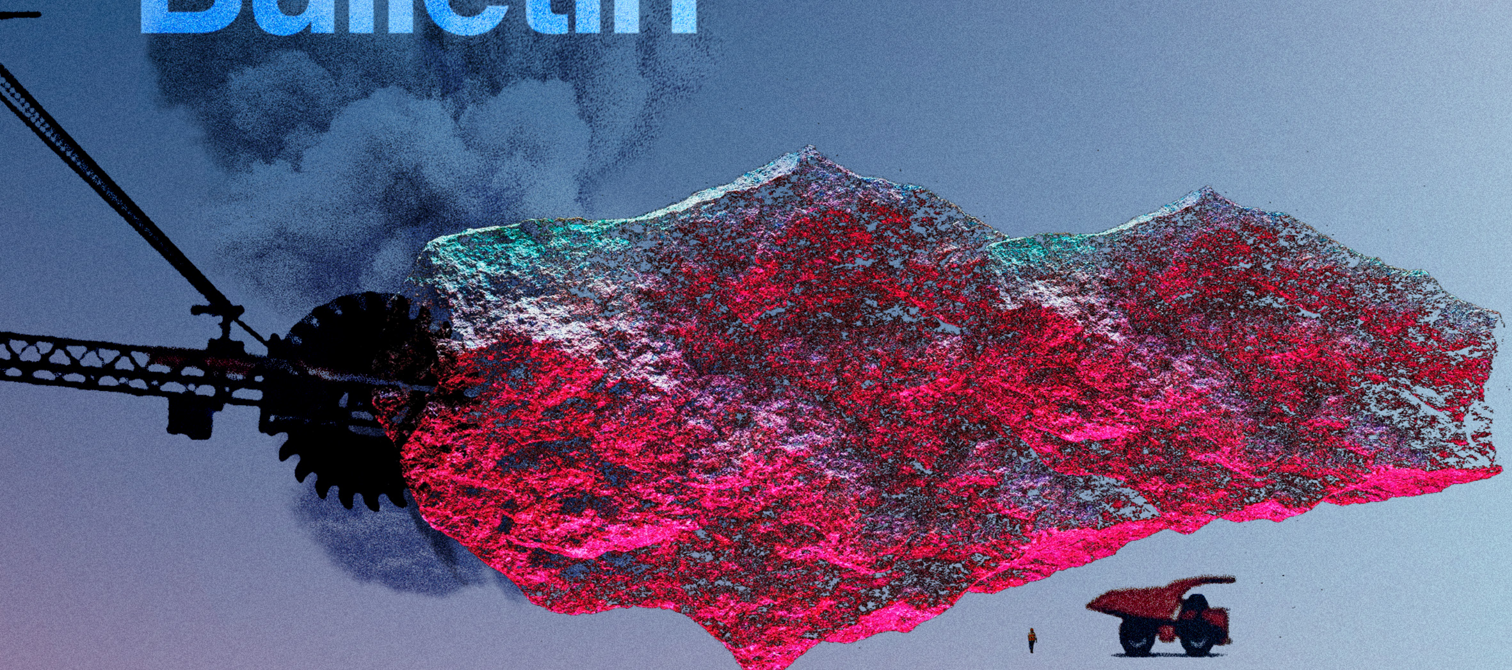

THE GLOBAL SCRAMBLE TO SECURE CRITICAL MINERALS: GEOPOLITICAL, ECOLOGICAL AND PLANETARY RISKS

Index

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Summary[1]

The global energy transition requires a rapid shift from fossil fuel dependency to mineral extraction. This shift is fueling exponential growth in demand for critical minerals, the backbone of clean energy and a vast range of advanced digital technologies. As a result, many new mining projects will need to be developed over the next decade in order to prevent supply bottlenecks. Notwithstanding the dominance of a few countries in the processing and application of critical minerals, a significant portion of the supply is located in countries of the Global South, many of which are highly unequal, fragile and/or conflict affected-settings. These areas are also highly susceptible to climate vulnerabilities, and the race to secure critical minerals is occurring alongside global escalating geopolitical tensions and intense national debates around just ecological transitions, across both Global North and Global South countries. Far from costs and risks-free, the implications of these transitions are civilisational, planetary, and existential. Decisions about where and how mining operations are established will shape the future trajectories of climate and ecological change. Who mines these minerals will likewise influence the global economic and technological balance of power, particularly as the fourth industrial revolution gains momentum. Moreover, the methods employed in mining critical minerals will have a profound impact on global stability, equity, and justice. Taking the pulse of the energy transition and the stakes involved requires a deeper examination of critical mineral dynamics, particularly in the Global South. Risk reduction should be a central focus of policies and supply chains dedicated to transitioning the global energy system in a way that also upholds economic, social and environmental justice both between and within countries.

Introduction

Notwithstanding repeated warnings from climate scientists and increasing investment in renewable energy, the world is racing past the 1.5°C temperature threshold established by the Paris Climate Agreement.[2] There is growing acknowledgment that transitioning energy systems away from fossil fuels toward cleaner power sources is more urgent than ever. The stakes could not be higher: decarbonisation is critical to avoid exponential climate change, planetary tipping-points, ecosystem shifts, and the breakdown of human civilization. However, the energy transition comes at a significant cost. In order to transition away from fossil fuels, the world must drastically scale up mining operations and build robust supply chains for critical minerals to be extracted, processed, transformed, and assembled into clean technologies.[3]

This shift from fossil fuel dependency to mineral extraction brings a host of transition risks that intersect dynamically with global and national inequalities, as well as climate- and environment-related risks. These risks include the physical degradation of fragile ecosystems due to mining activities, the threat of elite predation, resource-based conflicts, and pervasive human rights abuses.[4] Additionally, because the energy transition is intertwined with industrial and technological competition amid global power shifts, critical mineral supply chains are exacerbating geopolitical and geo-economic tensions.These tensions not only threaten the energy transition itself but also create risks of derailment on a global scale.

Although mineral extraction for the clean energy transition is less harmful than fossil fuel exploitation, it still involves numerous risks.[5] Risk reduction should be a central focus of policies and supply chains dedicated to transitioning the global energy system in a way that also upholds economic, social and environmental justice. The location of mineral mining plays a key role in understanding the ecological, socio-economic, and political risks associated with extraction and processing. Assessing the concentration or diversification of mineral supply chains, as well as identifying who controls mining and processing, can help policy makers anticipate the geopolitical and geo-economic challenges tied to the global energy transition.

This edition of the Global Futures Bulletin is structured into four sections. The first section provides foundational insights into critical minerals and their role in clean technologies. The second section outlines global risks associated with mineral extraction, focusing on climate vulnerabilities, biodiversity collapse, regeneration priorities, and governance challenges.The third section focuses on risks specific to highly unequal, fragile and conflict-affected contexts, highlighting patterns of risks that are likely to emerge and persist as mining ventures increase across the Global South. The final section offers a brief analysis of the geopolitical dynamics driving the competition for critical raw material supply chains, and their role in exacerbating risks, conflict and violence in the Global South.

Section I. The rising demand for critical minerals

Global decarbonisation heavily depends on the mining of various metals and minerals. Critical minerals form the backbone of the twenty-first century industrial and technological revolution,[6] which underpins strategies for mitigating climate change. While dozens of critical minerals are essential, Table 1 highlights some of the most vital to energy transition value chains. Each country defines its strategic critical minerals differently, based on their perceived importance to national goals and priorities.

Table 1. Critical minerals and their applications

Lithium: Known for its high electrochemical potential, lithium is a key component of lithium-ion batteries used in electric vehicles (EVs) and carbon capture and storage technologies.
Cobalt: Essential for lithium-ion batteries, cobalt prevents overheating and enhances durability.
Nickel: Ensures high energy density and chargeability in lithium-ion batteries.
Manganese: Used to produce a variety of important alloys and for deoxidizing and desulfurizing steel, manganese is a key material in several clean energy technologies, including wind, hydropower, geothermal, energy storage (batteries), and carbon capture and storage.
Graphite: Predominant anode material used in virtually all lithium-ion batteries. While cathode materials like lithium, nickel, cobalt, and manganese often take the spotlight, graphite remains irreplaceable.
Rare earth elements (REEs): With unique magnetic, optical, and catalytic properties, REEs are critical for permanent magnets in wind, hydropower, geothermal, energy storage (batteries), and carbon capture and storage technologies.
Copper: A highly efficient conductor of electricity, copper is central to solar, wind, hydropower, geothermal, energy storage (batteries), and carbon capture and storage systems.
Tin: Known as the "glue" of metals, tin is used as a solder to create electrical connections in EVs, wind turbines and solar panels. Research suggests it could become a more effective anode material in lithium-ion batteries, potentially driving significant demand in the foreseeable future.
Platinum group metals (PGMs): Comprising six elements (platinum, palladium, rhodium, ruthenium, iridium, and osmium), PGMs serve as catalysts in fuel cells, converting hydrogen (fuel) and oxygen into heat, water, and electricity.
Indium: A component of indium tin oxide (ITO), crucial for solar panel technology.
Gallium: Used in electronic circuits, semiconductors and light-emitting diodes (LEDs), as well as power converters for EVs and solar panels.
Scandium: Found in solid oxide fuel cells (SOFCs) and high-strength aluminum alloys used in aerospace, 3D printing applications and EVs.

Cadmium: Used in nickel-cadmium (NiCd) batteries for laptop computers, mobile phones, camcorders and other electronic devices, and also in pigments, coatings, and electroplating.

Tellurium: Used mainly in alloys combined with copper and stainless steel to improve their machinability. Additionally, tellurium's semiconductor properties, when alloyed with cadmium, enables the conversion of sunlight into electricity, especially in photovoltaics and thermoelectric applications, making it a key material in solar panel technology.

Silicon: A core semiconductor for transistors which amplify or switch electrical currents and an essential component in EVs, solar panels, and wind turbines.

Chromium: Vital component in stainless steel and superalloys, chromium adds hardness and corrosion resistance to metals. Known for being the primary material of the plating on automobiles, it is key in clean energy technologies like wind turbines, hydropower, geothermal, carbon capture and storage, and energy storage (batteries).

Molybdenum: Enhances strength, electrical conductivity and resistance in steel alloys. Molybdenum is also crucial for solar panels, wind turbines, hydropower, geothermal, and carbon capture and storage.

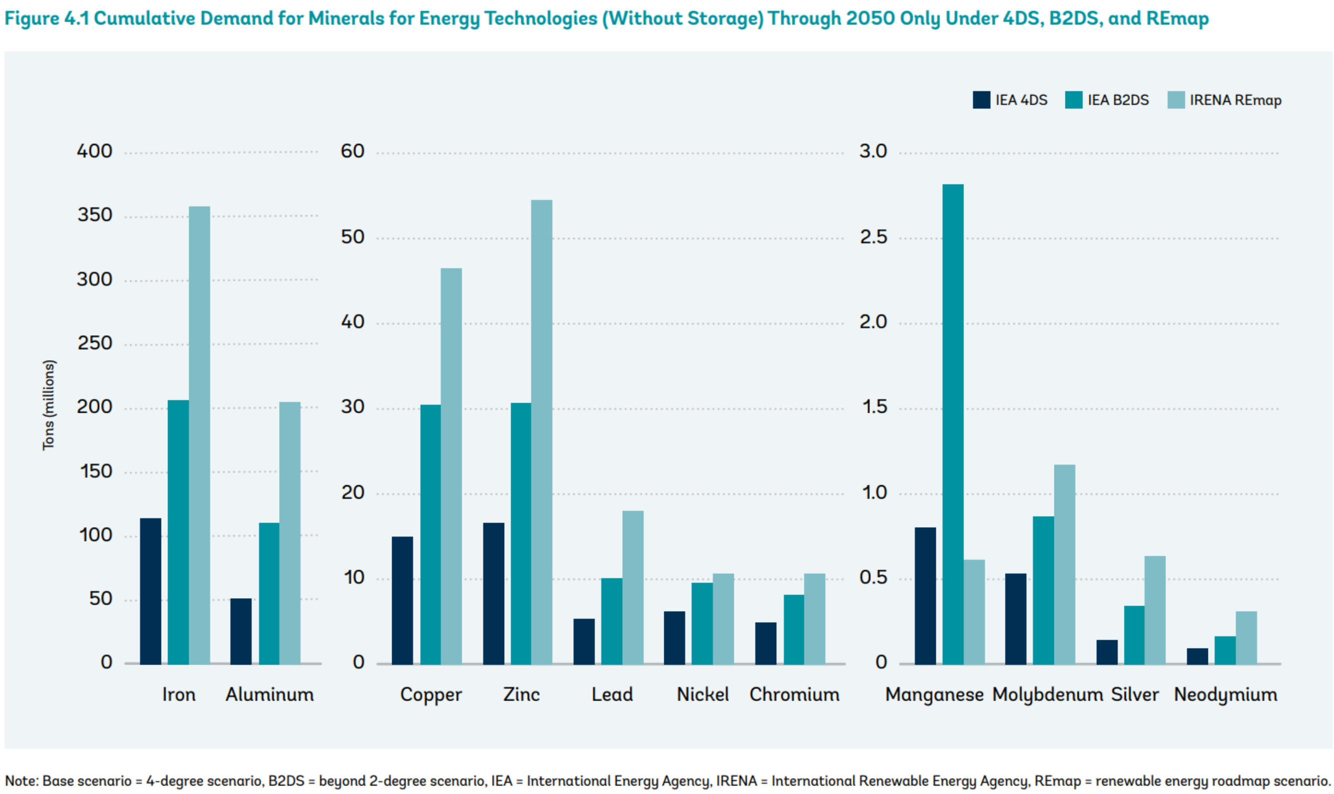
Zinc: Used to galvanize iron and steel, it also serves as an anode material in batteries, offering potential as a safer, cost-effective alternative to lithium-ion batteries in the global energy storage market.

Aluminum: Widely used in clean energy technologies for battery packaging, as a cathode, and in hydrogen fuel cells, aluminum is also a key component of wind turbine nacelles and blades, and in permanent magnets. Additionally, it is used in frames and inverters, making it a material of choice for power connection infrastructures.

Source: Ritchie and Rosado (2024) and International Renewable Energy Agency (Irena) -2021).[7]

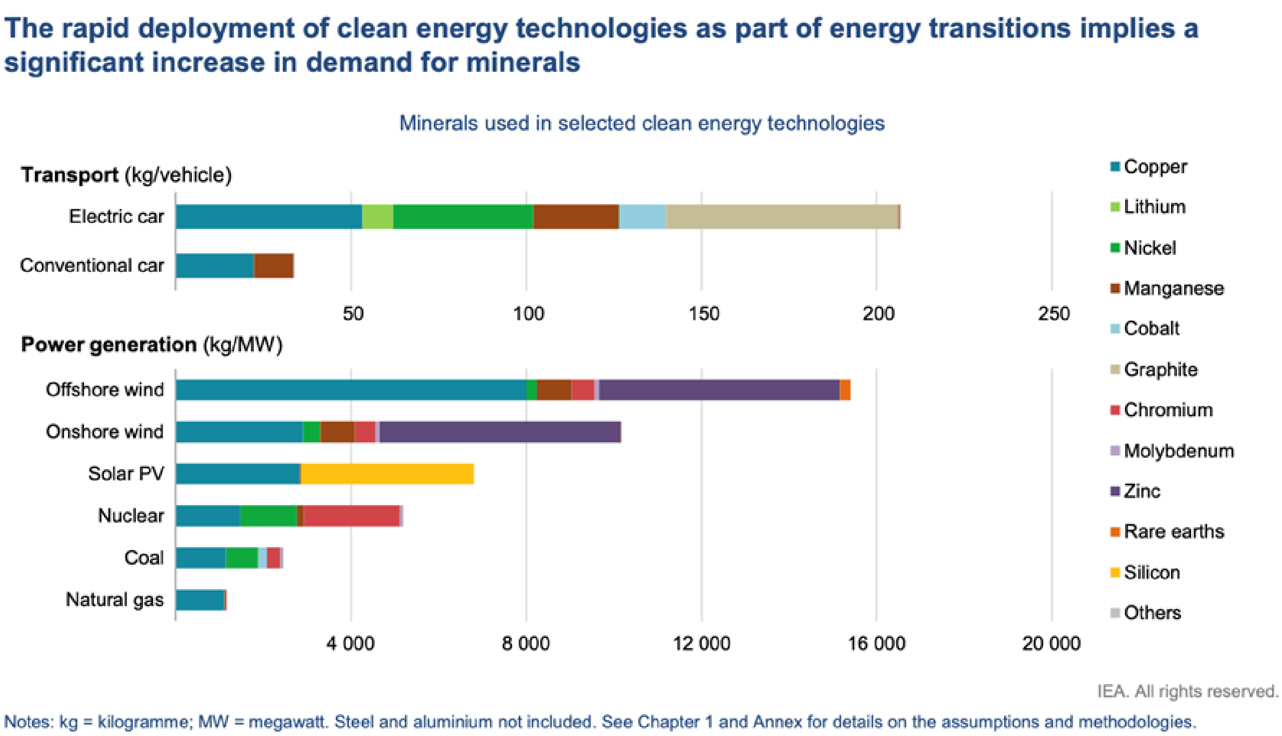
According to projections by the International Energy Agency (IEA), mineral extraction must increase sixfold to reach net-zero targets globally by 2050. The production of certain minerals, such as graphite, lithium, and cobalt, is expected to rise by up to 500% by 2050, as illustrated in the graph below.[8] Estimates from the IEA and World Bank outline broad demand trends for the coming decades. However, actual demand will depend on two key factors: efforts to curtail demand and technology-driven innovations, particularly in chemical transformations. In many ways, the transition to clean energy is as much a chemical shift as it is a mining transition.

Figure 1. Projected demand for selected minerals by 2050



Source: World Bank (2020). Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition.

Figure 2. Projected demand for selected minerals by 2050



Source: International Energy Agency (2021). The Role of Critical Minerals in Clean Energy Transitions.

Researchers are competing to develop optimal alloys and chemical compositions, especially for battery related storage technologies. The demand for minerals such as nickel or cobalt may fluctuate based on advancements in battery storage technology. For instance, sodium-based batteries require significantly fewer materials, which could drastically change demand projections for key minerals and metals. Beyond technological innovation, policymakers from regions like Europe, are exploring ways to reduce material demand, especially in the mobility sector. Over time, regulations aimed at limiting private EV usage, for instance, could further impact the demand for certain types of materials.

Dynamic shifts in technology and legislation pose significant challenges for mining companies and investors. Mining operations are capital-intensive and have long lead times before delivering returns on investments, making demand predictability crucial for mobilizing critical investments. When decarbonisation regulations or technological innovations are unclear or uncertain, private sector actors face difficulties in investing in relevant supply chains. Excessive fluctuations in commodity prices can weaken these supply chains, making them less resilient. Each mineral supply chain is influenced by unique dynamics, and collectively, these factors affect the speed and scale of investments needed to secure material supplies for the construction and deployment of global renewable/rebuildable technologies. Without adequate investments, supply bottlenecks for critical materials[9] could slow the pace of the energy transition.

Regardless of fluctuations in innovation and demand, the supply of Critical Raw Material (CRMs) must grow significantly in the next decade.[10] It is critical, therefore, to understand the risks connected to mining and to develop effective mitigation strategies. The current rate of mining is insufficient to meet the required supply levels. New mining projects, or so-called “greenfield” projects, are urgently needed. Benchmark Source estimates that about 384 new mines[11] will be required by 2035 to meet global storage demands for net zero objectives. While the precise number remains contested, this projection underscores the scales of mining necessary for the energy transition. It also raises a key question: where will these future mines be located?

While established mining powers such as Australia, Canada, China, Russia, and the United States dominate the industry, the majority of CRM deposits and reserves are found in the Global South.[12] These mines are often situated in areas marked by interrelated risks, including climate vulnerability, water stress, rentier economies, and multidimensional fragility. In some cases, these mines are located within vital ecosystems that play a key role in regulating the global climate, including the Amazon Basin. Beyond terrestrial reserves, exploration efforts are extending into ecological frontiers that remain largely untapped: the cryosphere, the deep seas, and, in some cases, outer space.

The geography of exploration and future exploitation raises concerns about a new scramble for resources with potentially devastating consequences for local communities, including Indigenous and traditional peoples, and for multiple ecological frontiers. History serves as a reminder that the race to secure minerals often perpetuates and exacerbates structural forms of violence and inequality, both within and between countries. The social and ecological impacts of such exploitation can be profound and long-lasting. If structural inequalities are deepened, the Intergovernmental Panel on Climate Change (IPCC) warns that this could result in structural maladaptation to climate change, with far-reaching consequences for sustainable development.[13]

Increasing geopolitical competition is sharpening the race for CRMs. These critical minerals are not only central to decarbonisation but also to digital transformation and industrial and defense supply chains. They are essential for economic, energy and national security.[14] Yet, CRM supply chains – from mining to processing, refining and technological innovation – are marked by significant power asymmetries. China was a first mover in several CRM supply chains critical to modern economies, including rare earth extraction, refining and processing.[15] China has advanced a state-backed model that has also enabled extraction in third party countries in the Global South.

China's influence on CRM supply chains is far-reaching and could take decades to structurally re-balance. Even so, the EU, U.S., Japan, Australia, Canada and other nations are making efforts to counter Chinese dominance.[16] With a few countries dominating CRM supply chains (notably China[17] but also a few advanced economies in the Global North), energy- and technology-intensive countries are actively working to mitigate their dependencies.

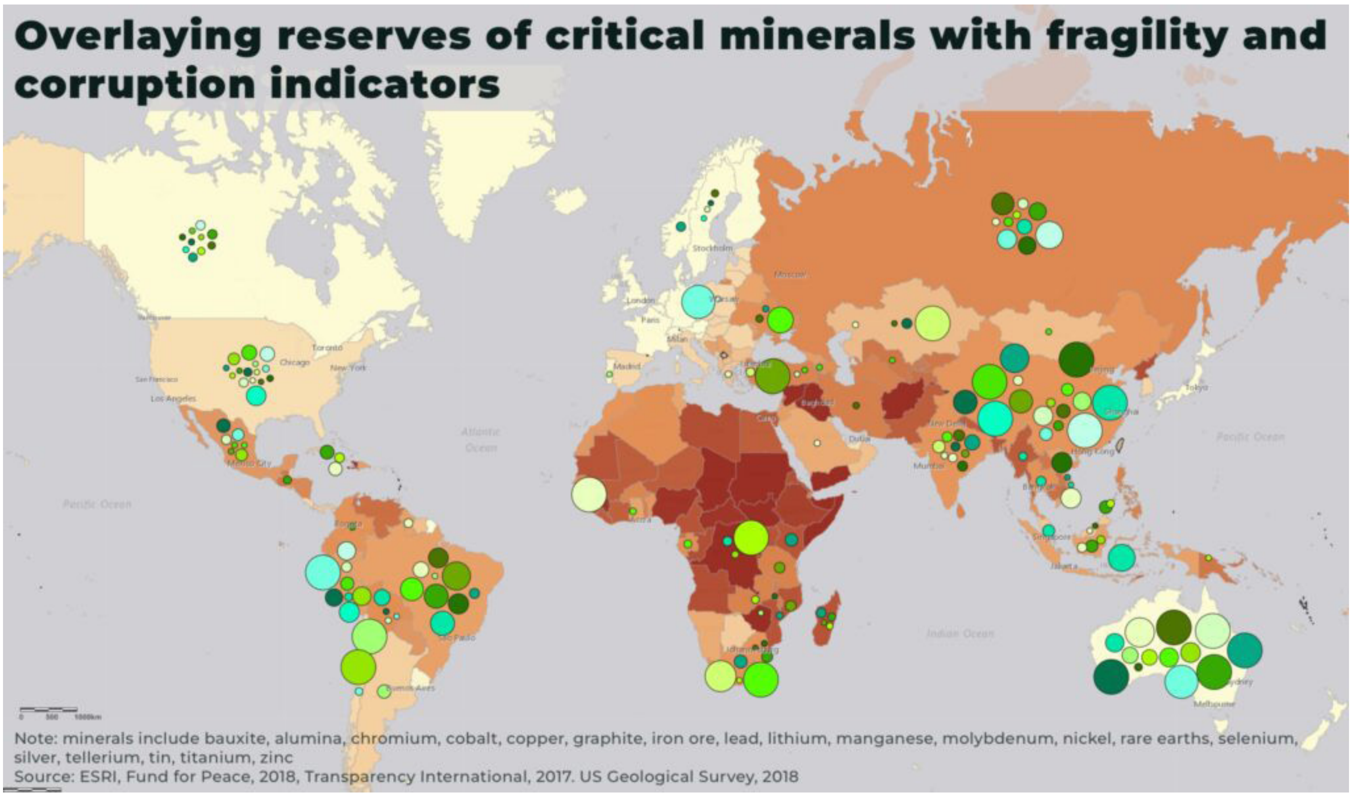
At the same time, CRM-endowed countries in the Global South find themselves in a cross-roads of these diversification efforts. Having experienced other extractive industries-related waves in the past, many are are auctioning off their resources to competing geopolitical actors, seeking to capture as much economic benefit as possible from this new rush to secure CRMs. Yet, these negotiations are often asymmetrical and largely limited to the economic domain. Issues such as climate, water, ecological security, and governance issues are not fully integrated into the conversation between supply and demand countries. These overlooked factors, however, are likely to shape the security dilemmas of the future.

Section II. Risk layering in the Global South and implications for ecological and planetary security

Critical Raw Materials (CRMs) are geologically distributed across the globe. While geological research has mapped many existing resources, national survey services continue to actively search for new reserves that could be viable for exploitation. Traditional mining powerhouses such as Australia, Canada, Russia, and the US, remain dominant players. However, today's most promising deposits and reserves for rapid exploration and exploitation are found in regions such as Africa, Central Asia, Latin America, the Western Balkans, South East Asia, and the Arctic.[18] Additionally, many types of deposits and suspected reserves are located in the deep seas and possibly in space. Countries publishing CRM lists are working to secure their supply chains, but the regions hosting these resources often face several risks, raising serious questions about how best to capture the long-term developmental benefits of mining activities.

Consider that 21 of the 37 fragile and conflict-affected situations identified by the World Bank in 2021 host sizable CRM reserves.[19] For instance, the Democratic Republic of Congo (cobalt), Mozambique (graphite), Myanmar (rare earths), and Zimbabwe (platinum) rank among the world's top producers.[20] In these and other countries, pre-existing conditions such as recent histories of conflict, high inequality, endemic corruption, low social cohesion, systematic human rights abuses, and the presence of non-state armed groups significantly elevate risks. Under these conditions, CRM extraction can exacerbate instability while failing to deliver inclusive prosperity or sustainable development (see Figure 3).

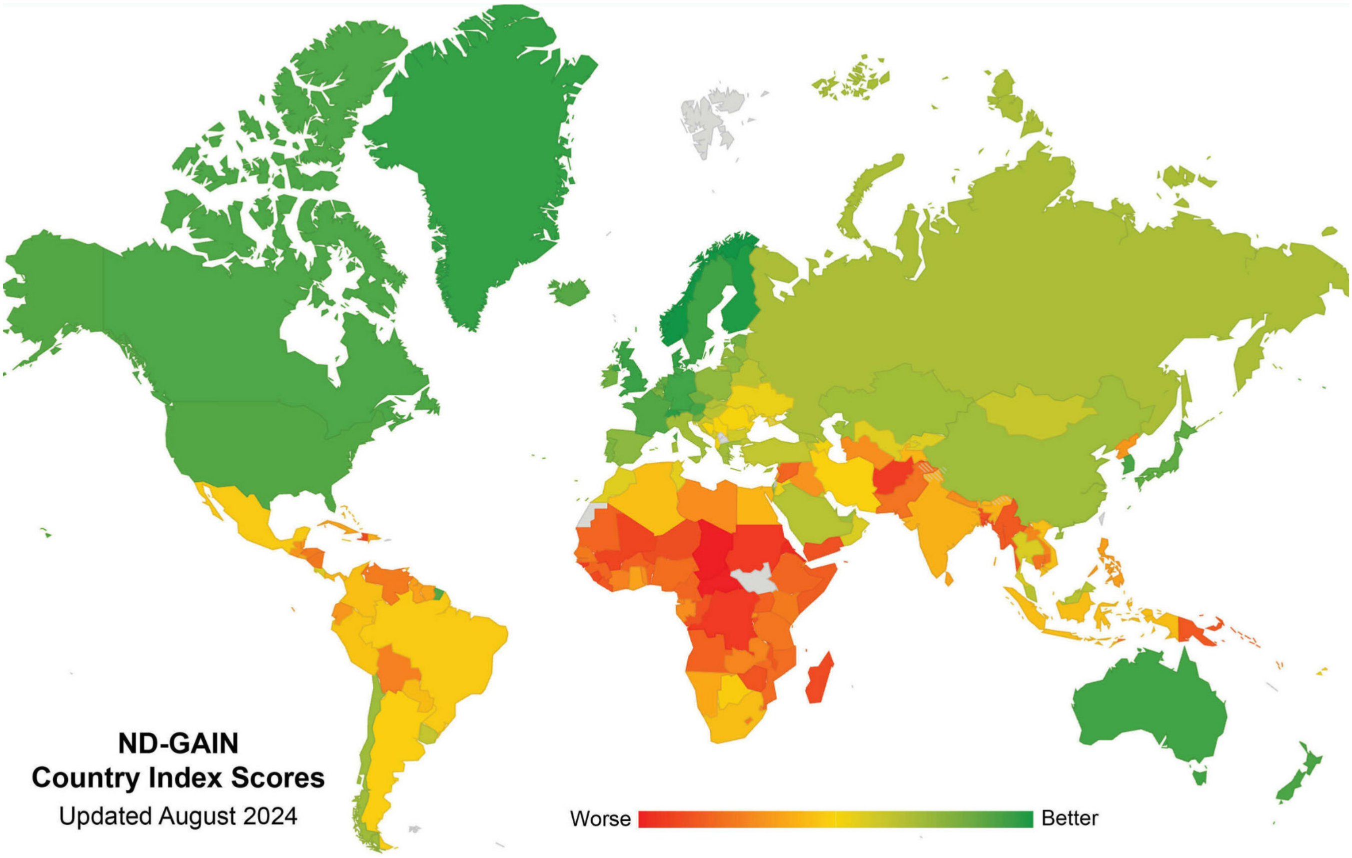
Figure 3. Fragile states and critical minerals reserves



Source: Map provided by the Oregon Group (2023) based on ESRI (2018), Transparency International (2017), and US Geological Survey (2018).[21]

A significant portion of known CRM resources is located in countries that are highly vulnerable to the immediate and devastating impacts of climate change (see Figure 4).

Figure 4. Notre Dame GAIN Index on climate adaptation and vulnerability (2023)



Source: ND-GAIN (2024)[22]

Indeed, climate hazards have significant effects on active mining areas, impacting everything from mining pits to tailings sites. Storms, floods, and landslides can place tremendous stress on mining operations and disrupt chemical-intensive industrial sites, including tailings management. If tailings management structures, such as dams, fail, they can release severe and long-lasting chemical pollutants, harming communities and ecosystems.

Climate change further exacerbates water stress, particularly in regions already experiencing acute shortages.[23] Climate impacts on local hydrological cycles compound the anthropogenic impacts of mining on water resources. For example, northern Chile faces high rates of water evaporation due its local arid climate, a condition that will worsen with climate change. In the Atacama and Antofagasta regions, mining accounts for 70% of water extraction,[24] creating direct competition with other economic sectors such as tourism, agriculture and conservation. As Chile plans to expand its mining activities in the future, critical questions arise about the long-term impacts on the region's climate adaptation efforts, which depend heavily on resilient water availability and sustainable hydrological cycles.

The IPCC has highlighted how climate stresses, latent fragility, and structural maladaptation are often interconnected.[25] Predatory political economies, frequently linked to extractive industries, undermine accountability within political systems and intensify structural risks such as marginalization and inequality. In some cases, these factors can escalate into violence and conflict. Climate stresses and hazards also weaken resilience, compounding pre-existing structural vulnerabilities. This is why climate change is often referred to as a "risk multiplier", especially in fragile contexts.[26]

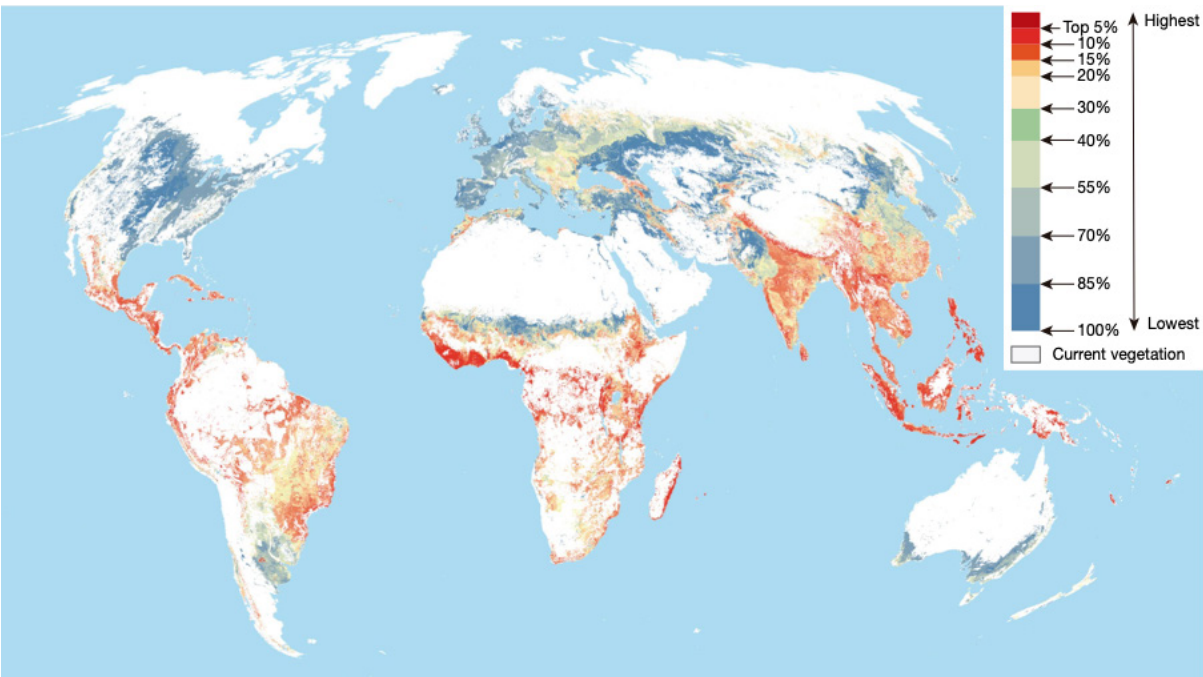
A pressing concern with the energy transition is that extractive economies may foster more predatory political economies, exacerbating fragilities connected to climate change. One implication is the need for the energy transition to be managed in a way that ensures mineral supply chains not only avoid heightening risks but also actively support fair, sustainable, climate-adaptive development. Failing to do so risks deepening structural inequalities, exacerbating the effects of climate change, and undermining core development goals.[27]

Currently, around 20% of all mines worldwide are located in regions classified as biodiversity hotspots.[28] For instance, the production of niobium (Brazil), platinum (South Africa), arsenic (Peru), nickel (Indonesia), cobalt, and tantalum (Democratic Republic of Congo) takes place in "mega-diverse" areas, according to the United Nations Environment Programme (UNEP). These countries host critical endemic species and support exceptionally high levels of biodiversity. However, extensive extractive ventures in such countries can lead to significant environmental degradation, deepen the biodiversity and water scarcity crisis, and accelerate climate disruptions at local, regional and even global levels.[29]

It is worth noting that several mining actors are advancing rapidly in the field of biodiversity offsetting.[30] This practice involves extensive pre-extraction studies aiming at mapping, safeguarding, and protecting species that will be affected during exploitation phases. Paradoxically, in some contexts, mining operations not only contribute to improved biodiversity protection but also facilitate broader biodiversity research and the generation of related public goods. This emerging field warrants attention, as it extends beyond the traditional scope of Environmental Social and Governance (ESG) standards.

However, it is important to emphasize that even under the most ideal circumstances, mining has profound and far-reaching impacts on ecological integrity. Many of these impacts are difficult to monitor due to the undeveloped state of ecological service science. Even with biodiversity offsetting strategies in place, disturbing complex ecosystems inherently disrupts ecological interdependencies that remain poorly understood.

Figure 5. Global regeneration priority areas



Source: Strassburg et al (2020). Global priority areas for ecosystem restoration.

The dangers of mining to planetary security were already present but become more evident when considering global regeneration priority areas. Critical mineral resources are often found beneath key ecosystems worldwide, particularly in pan-tropical areas,[31] which play a vital role in nature-based solutions for combating climate change. These ecosystems serve multiple functions: they sequester carbon dioxide, stabilize the global climate, and host massive biodiversity essential for species reproduction, evolutionary processes, and protection against zoonotic diseases. Additionally, they support teleconnections, such as biotic pumps and atmospheric rivers, which are crucial for maintaining global hydrological cycles.

Tropical forests, for instance, generate their own hydrological cycles in connection with marine ecosystems and distribute moisture to other areas through atmospheric rivers. Paradoxically, the overlap of mineral deposits with global regeneration priority areas highlights inherent tensions between nature-based and industrial responses to climate change, which were originally envisioned as complementary. In practice, however, global net-zero strategies reveal conceptual flaws that urgently require solution. Integrated planning and management of land and marine use, alongside greater emphasis on sustainable development outcomes for local communities near mining operations, must be rapidly developed to reconcile these competing demands.

The implications of mineral deposit overlap with global regeneration priority areas become even more pronounced when considering the case of the Amazon. Figure 6 illustrates key teleconnections among ecosystems that are fundamental to planetary stability. This schematic representation demonstrates how global warming disrupts teleconnections between the atmosphere and biosphere, starting with polar ice melt, weakening oceanic belt mechanisms, and ultimately affecting critical carbon sink ecosystems, including the Amazon.

The Amazon is a vital component of the interconnected systems that stabilise the global climate regime and drive meteorological patterns worldwide. It plays a crucial role in distributing water across South, Central, and North America, as well as reaching Europe and Africa. However, parts of the Amazon are already showing signs of potential dieback or savannization[32] due to extensive deforestation and pressures from global warming. Currently, cattle ranching and agriculture are the primary drivers of deforestation in secondary forests.[33]

In contrast, mining is more likely to take place in the primary forests of the Amazon.[34] Primary and secondary work together to sustain the biotic pump effect, functioning symbiotically. If agriculture and mining pressures were to converge, impacting primary and secondary forests, it could disrupt the biotic pump effect, leading to the collapse of the Amazon's hydrological role on the planet. Beyond the breakdown in water cycling, the Amazon dieback would trigger cascading effects on other teleconnected tipping points. While the full planetary consequences of such a scenario remain uncertain, they would undoubtedly push the biosphere closer to a systemic shift in the global climate.

Mining of copper, tin, nickel, bauxite, manganese, iron ore and gold (and increasingly so niobium) already takes place in the Amazon. In some areas, small-scale illegal gold mining has already destroyed entire regions (like Madre de Dios in Peru or the Yanommai and Munduruku Indigenous Lands in Brazil).[35] But the new rush can fuel even more destruction.

Figure 6. Tipping point teleconnections

Source: Armstrong McKay et al, (2022). Exceeding 1.5°C global warming could trigger multiple climate tipping points.

Deforestation linked to mining generates far more negative externalities than the mere release of greenhouse gases. It also undermines the ecological integrity of critical planetary pillars. The full extent of mining-induced deforestation worldwide remains unknown. However, in major tropical basins, over 3,200 km² of rainforest were lost between 2000 and 2019 in just four countries: Brazil, Indonesia, Ghana, and Suriname.[36] Beyond direct pit-related deforestation, mining often causes indirect forest loss due to the construction of industrial activities and transportation networks. Indonesia has been particularly affected, losing nearly 2,000 km² of pristine forests during the same period, much of it due critical mineral exploration and extraction.[37]

In Brazil, mining activities— both industrial operations and small-scale mining, known as *garimpo* — currently occupy approximately 307,000 hectares in the Amazon. As of 2022, over 90% of all surface area affected by *garimpo* activities in the country was concentrated in the Brazilian Amazon. Alarmingly, no less than 186,000 hectares are situated within 0.5 kilometers of watercourses, posing significant environmental risks.[38]

The broader relationships between mining, climate, and ecological change remain poorly understood, especially beyond the limited lens of greenhouse gas emission, which alone fails to capture the full scope of planetary changes at play. This represents a significant scientific blind spot as humanity embarks on the most ambitious energy transition in history. A key challenge lies in the fact that mining impacts are typically assessed on a project-by-project basis, focusing on localized or national risk mitigation rather than on aggregate levels at regional, international or planetary scale.

The energy transition, however, requires the opening of hundreds of new mines over the next two decades to meet the material intensity required, not just for clean energy but also for digital and defense transitions. The combined and aggregate impacts of these activities on ecosystems are difficult to evaluate, yet they will undoubtedly interact with and exacerbate existing planetary boundary crises that are already in overshoot.

The layering and gradation of climate, adaptation, and planetary risks reveal a broader picture than what is typically discussed regarding critical minerals. CRM debates are often framed around geopolitical and geo-economic de-risking, economic and defense security, and supply chain diversification. While these issues are undoubtedly important, they fail to address the planetary, ecological and social-economic justice stakes at hand, limiting opportunities for constructive international cooperation. Instead, international discussions on CRMs tend to focus on bargaining within the context of power shifts and competitive offers, effectively paving the way for a resource scramble driven by power competition.

Jurisdictions in the Global South play a central role in supply chain diversification, primarily due to their deposits and resources. The future of planetary stability will largely depend on how these countries manage exploration, extraction, and processing within their territory. Key questions include whether they can balance extraction with natural protection and regeneration, and whether the energy transition can promote planetary and international security by narrowing, rather than widening, structural inequalities and economic gaps, and fuelling conflict and violence.The scramble for resources in the Global South already reveals discernible patterns of risk. If these risks materialize, their consequences will extend across political, ecological, economic, and socio-cultural dimensions, with the potential to escalate to the planetary scale.

Section III. Exploring patterns of vulnerability and fragility

Multiple patterns of risk are apparent in relation to extraction in highly unequal, fragile, conflict and violence-affected settings. These risks stem from governance and accountability gaps and bottlenecks in and around mining projects that fail to consider the needs of impoverished communities, the equitable redistribution of economic dividends, or long-term planning for sustainable development. Such planning should ideally connect private sector activities to broader public strategies for economic diversification and infrastructure development. In some cases, extraction occurs in the midst of armed conflicts, directly and indirectly fueling war economies.[39]

While each of these risks is important on its own, they become more pronounced in a climate-disrupted world. Weak governance and structural inequalities reduce a country's ability to adapt to climate challenges and often exacerbate long-standing inequalities. Furthermore, mining in fragile countries often occurs under less stringent standards due to poor enforcement of regulations. This combination of weak governance and ecological exploitation links multidimensional fragility with environmental degradation. In turn, these degraded ecosystems undermine planetary systems that are critical for stabilizing the global climate regime.

Conflict, violence and fragility

Mining can reinforce pre-existing fragility and exacerbate conflict. In countries already grappling with conflict and political or economic fragility, extractive sectors are often positively correlated with elite capture, corruption, violence, inequality, and structural marginalization of key populations.[40] These contexts frequently lack transparency regarding rules for deposit acquisition, extraction economics, and the redistribution of gains,[41] making them particularly vulnerable to the politicization of resources, elite manipulation, and foreign influence.[42]

This dynamic is a tacit element of the new scramble for resources. As critical minerals become increasingly essential for energy, economic, and defense security, access to current and future mineral resources is key, along with the infrastructure to connect these resources to processing, has become paramount. China, Russia, the U.S., European countries, and Saudi Arabia actively compete for geological survey contracts, deposits, exploration and extraction concessions through private and state-sponsored companies.

In fragile and conflict-affected countries, access to information and assets is often skewed through corrupt practices, elite sponsoring, influence campaigns, and extensive political bargaining. For example, in 2019, Russian oligarchs financed the presidential campaigns of several candidates in Madagascar, including the former and current presidents.[43] In return for financial backing, Ferrum Mining and Stork – two Russian companies associated with the Wagner/Afrika Corps group – secured concessions for the two most prolific quarries by the country's sole national mining company responsible for chromite extraction.[44]

Russia is active in several fragile contexts across the Global South, often employing unconventional methods to secure access to mineral and hydrological assets. These efforts are part of a broader strategy to position itself as a key powerbroker in the supply chains shaping the global energy transition and, more widely, to shift the global balance of power in its favor.[45] However, Russia is not the only actor in this competition. As mentioned, many other countries are already competing for access to critical minerals supplies. Growing competition and economic nationalism — at both the demand side and supply sides — can contribute to weaking governance in already fragile and/or conflict and violence-torn contexts.

The degradation of governance in countries of the Global South exacerbates ecological and socio-economic frailties. Sovereign governance systems are critical to ensuring the provision of public goods, sustainable development, ecological health, and climate resilience. In fragile settings however, corruption, predatory practices, and elite bargains often undermine these objects. Officials may become captive to private sector interests or foreign influence, further weakening governance systems.[46] These dynamics have serious implications, as it can perpetuate and intensify risks in already fragile contexts, amplifying challenges for sustainable development and resilience.

Integrity, law-enforcement and sovereignty-related challenges in resource management and governance can intensify the risks of national and subnational public good distortion, contribute to ecological degradation, hinder development, and exacerbate resource curses. While corruption and predatory practices have long been persistent challenges for governments, they have gained renewed urgency due to extraction models that instrumentalize these behaviors as part of their business model (see Box 3). On a more positive note, there is a growing attention to compliance, transparency, and human rights standards, particularly in response to global climate and biodiversity commitments.

Box 1. **Mining risks in a conflict zone – the case of Myanmar**

Myanmar hosts over 60 key minerals distributed along eight mineral belts. The country holds significant deposits of copper, lead, zinc, tungsten, gold, coal and barite, alongside antimony, silver, nickel, gypsum, iron and manganese. Additionally, it has smaller quantities of industrial minerals such as chromite and bauxite.[47] In 2019, Myanmar became the third-largest official producer of Rare Earth Elements (REEs) after China and the United States. According to the US Geological Survey, over 30,000 tons of rare earths were mined in Myanmar in 2020, including substantial deposits of heavy rare earth elements (HREEs) like dysprosium and terbium.

Rare earth mining in Myanmar is primarily concentrated in Kachin state, a region with a long history of ethnic insurgency and the involvement of armed groups in REE extraction. Some sources trace the origins of rare earth mining in Kachin to areas controlled by the Kachin Independence Army/Kachin Independence Organization (KIA/KIO) in the years leading up to the collapse of a ceasefire with the Tatmadaw in 2011.[48] Historically, the KIA/KIO's primary income source is illicit jade mining.

Today, rare earth mining occurs in areas under the control of "ceasefire groups" led by Kachin warlord Zakhung Ting Ying, the former leader of the New Democratic Army-Kachin (NDA-K). Local activists report that Zakhung Ting Ying's Border Guard Force (BGF) profits significantly from rare earth mining through partnerships with Chinese-backed companies. These groups impose illegal taxes and accept bribes in exchange for allowing unregular activities. This model mirrors similar practices involving opium poppy farmers and tissue-culture banana plantations in Waingmaw township.[49]

This model results in widespread abuses of both human and environmental integrity. Rare earth metals in Myanmar are extracted using a process called "in-situ leaching", where ammonium sulfate solution is injected into mountainside holes to dissolve the earth and extract metals. The process leaves behind toxic turquoise pools; satellite imagery gathered by Global Witness identified 2,700 such pools in nearly 300 locations.[50] When these pools are not properly sealed, chemicals leak and contaminate groundwater. In December 2019, villagers in Chipwi Township reported that the nearby river – which flows into the N'Mai Kha River – had turned red as a result of hazardous mining waste. The N'Mai Kha River is a major tributary of the Irrawady River, whose basin supports two-thirds of Myanmar's population.

In addition to the environmental impacts on their natural resources, locals in Kachin State faced land seizures as militia-backed mining companies confiscated farmland, often offering compensation without negotiation. According to a 2019 World Bank report, "Land tenure in Myanmar is extremely insecure, due to incomplete legal frameworks, incomplete land records, and poor administration services (survey, cadaster and registration).[51] In February 2022, after two local militia leaders threatened to shoot village representatives who refused to give up their land, community leaders in Kachin wrote to the military's Northern Command, seeking to stop expansion of mining projects.[52]

Nearly all of the heavy rare earth elements (HREEs) mined in Myanmar are exported to China. In 2010, China accounted for 95% of all officials of rare earth extraction. However, since 2015, China has tightened environmental regulations of its domestic rare earth sector, leading to the closure of mines in Jiangxi Province. As a result, China's state-owned processors have increasingly turned to neighboring Myanmar for raw materials. Between 2014 and 2020, official Chinese imports of rare earth elements from Myanmar surged from 300 tons to 35,000 tons, valued at U$388 million.[53]

According to an industry report, between 2016 and 2019, approximately 16,000 people relocated from Ganzhou in China to Myanmar for mining activities.[54] Local press reports in Pangwa, Chipwi Township, reported a fivefold increase of Chinese mine workers in Kachin State following Myanmar's 2021 coup. A 2018 survey of residents revealed that Chinese workers comprised nearly half of the 30 to 100 employees at each mine, primarily occupying managerial and skilled positions, while local workers undertook manual labor, including hazardous tasks involving dangerous chemicals.[55]

Despite Myanmar law prohibiting foreign investment in small- and medium-scale mineral production, Chinese-backed companies circumvent regulations by partnering with Myanmar-registered firms. These firms may also apply for exemptions from the central government, though none have been officially granted. Taxes and bribes are often collected by local authorities and armed groups in exchange for mining permissions, often on confiscated land. In Kachin State, local militias bypass central immigration controls by issuing unofficial permits to Chinese mine workers.[56] By 2020, 94% of the rare earth elements officially imported by China came from Myanmar.[57] Between May 2017 and August 2021, China Customs recorded the value of rare earths imported from Myanmar at approximately U$1.1 billion.[58]

Understanding governance challenges (including corruption) and the evolution of Myanmar's political and conflict periods is key to understanding the strategic value of extraction in relation to Chinese interests abroad and the Junta's hold on the country. The central mining legislation is the 2015 Mines Law, enacted during the final months of President U Thein Sein's administration. The law introduced a framework for mining licenses, fiscal regime, and royalty rates; outlined the responsibilities of central, regional, and state governments; and established mine inspections and penalties for non-compliance. The reform aimed to gradually transfer responsibility for mining inspection and regulation to local authorities, granting Regions and States the authority to issue permits for small-scale and artisanal mining.[59] In February 2018, Amended Mining Rules were introduced to address investor concerns regarding licensing arrangements, fiscal regimes, and environmental requirements. These amendments clarified the processes for obtaining mining permits, outlined the obligations of permit holders, and established rules for mine closures, safety, labor, accidents and inspections.[60]

The Ministry of Natural Resources and Environmental Conservation (MNREC) was established in 2016 following the merger of the Ministry of Mines – which included six State Economic Enterprises (SEEs) and two administrative departments – and the Ministry of Environmental Conservation and Forestry. Within the MNREC, the Department of Mines oversees mineral policy and royalties collection, while the Department of Geological Survey and Mineral Exploration (DGSE) conducts geological surveys and mineral exploration. During the civilian government, two parliamentary committees,representing the upper and lower houses of parliament, actively addressed the extractive industries sector.[61]

Since 2014, Myanmar has published records of mining permits as part of its commitments under the Extractive Industries Transparency Initiative (EITI). However, many permits have been issued to companies that did not register with Myanmar's Directorate of Investment and Company Administration. According to Myanmar EITI records for 2016-17, 148 mining permits were issued in Kachin State, with half of them granted in areas controlled by Zakhung Ting Ying's militias. None of these permits were for rare earth exploration or production, focusing instead on iron, tin, tungsten, marble, lead, and zinc.[62] In 2019, the civilian government twice closed the border with China in an effort to crack down on unregulated mining by Chinese operators.

Since the February 2021 coup, the Ministry of Natural Resources and Environmental Conservation has been under military control. The regime's financial gains from rare earth mining align with the military's decades-long practice of funding itself through illicit extraction of jade, gemstone and timber. In Kachin state, armed groups have used revenues from illicit gold, copper, and iron to finance insurgency.[63]

Myanmar's situation highlights a critical but often overlooked aspect of the extraction economy: conflict serves as a business model that externalizes costs and damages onto vulnerable populations who often face rights abuses and lack meaningful political representation. Advocating for labor, political, environmental and social rights in such circumstances is not only difficult but dangerous. Accountability is completely reversed, prioritizing geopolitical interests that sustain conflict economies and elite bargains rather than fostering conflict resolution, stabilization, and development.

This dynamic is especially true during periods of heightened geopolitical tensions and fragmentation. The scramble for resources unfolds within a systems rivalry, driven by competing ideological and political objectives rooted in extraction, industrial, and technological competition.

Violence against Indigenous peoples and environmental defenders

While extraction can sustain conflict economies and perpetuate structural violence, other forms of violence are also associated with mining. Notably, 54% of mining concessions related to the energy transition overlap with Indigenous lands,[64] placing land-linked peoples at particularly high risk of structural and direct abuse.[65] These challenges are particularly acute in countries like Brazil (see Box 2). Beyond concerns about violence, the overlap between mineral deposits and Indigenous lands raises two fundamental issues.

The first issue is one of justice. Indigenous peoples have suffered profound injustices since colonial times and have fought to secure legal protection for their land and for their culture. However, in the face of growing imperatives linked to energy and national security across various countries, their rights are at a greater risk of being curtailed.

The second issue concerns the threat to Indigenous lands as the source of nature-based knowledge and wisdom. These lands not only sustain Indigenous peoples but also serve as reservoirs of critical knowledge about working with nature in the fight against climate change. The overlap between deposits, critical ecosystems, and Indigenous lands underscores a fundamental challenge in the energy transition: if the transition results in the plundering of ecosystems and the erosion of Indigenous land-based cultures, it will ultimately undermine the very complexity of life, human cultures, and wisdom that the transition seeks to preserve.

In other words, there is no wisdom in plundering the planet to save the climate. Finding the equilibrium between nature-based and energy-based solutions to the climate crisis is not just vital – it is an absolute necessity.

Box 2. **The encroachment of mines on Indigenous land in the Brazilian Amazon**

The case of Brazil illustrates some of the ways that mining interests have impacted Indigenous territories and protected areas. The Brazilian Legal Amazon is home to more isolated Indigenous societies than any other region on the planet, with at least 120 groups that live isolated from the majority society.[66] Indigenous lands, which were established to safeguard the rights of both isolated and non-isolated Indigenous peoples, cover 23% of Brazil's Amazon forest.[67]

In 2022, there were approximately 225 mining applications for various minerals, including copper, gold, nickel, potassium salts, zircon, cassiterite (tin), bauxite (aluminum), and diamonds.[68] These permit applications spanned more than 572,000 hectares. The state of Pará recorded the highest concentration of applications, with 143 overlapping 22 Indigenous lands, followed by Amazonas and Mato Grosso, with 56 and 23 applications, respectively. It is important to note that the number of mining applications in Pará doubled in less than six months, rising from 67 in July 2021.[69] By 2024, over 3,000 mining applications had been filed with the Brazilian National Mining Agency (ANM) covering 26 million acres – an area nearly equivalent to the size of England.[70]

The Indigenous lands most affected by mining applications include Xikrin do Catete and Waimiri Atroari, each with 34 applications, followed by Sawré Muybu (21 applications) and Apyterewa (13). The Kayapó territories are the most heavily impacted, with 73 applications, followed by Waimiri Atroari (34), Munduruku (25), Mura (14), Parakanã (13), and others. Additionally, at least five applications have been filed for areas where Indigenous people of the Apiaká ethnic group live in voluntary isolation.[71]

Indigenous communities in the Amazon have already suffered greatly from the expansion of both industrial and small-scale mining into their territories. As mentioned, in the last decade illegal small-scale gold mining has expanded across the Amazon, both in Brazil and in neighbouring countries. Mercury contamination, a byproduct of artisanal and small-scale mining (ASM) for gold, has reached alarming levels in Amazon rivers like the Tapajós and Uraricoera. This contamination has severely compromised the health of Indigenous peoples and riverside communities. Despite repeated denunciations by affected communities, little action has been taken to address these harmful practices.[72]

In addition to the well-known impacts of mining – such as deforestation, river degradation, and threats to life – there are less visible but equally significant consequences that often go unnoticed in environmental licensing and compensation processes. These include disruptions to the cultural, political, and social ways of life of Indigenous peoples caused by mining operations on or near their territories.

Far from being marginal, these impacts are deeply felt by communities, affecting individual and collective mental health, traditional forms of organization, and ultimately their ability to sustain themselves on their ancestral lands. Among these impacts are the desecration of sacred sites or restricted access to them, often due to limitations imposed by mining companies, such as being unable to conduct festivities and rituals in degraded areas (particularly rivers), as well as interruptions to daily life caused by the influx of people and heavy equipment near Indigenous communities.

Many communities also report exhaustion from the continuous cycle of meetings with companies regarding consultations and damage reparation. These processes frequently disrupt their political self-organization, for example, when company representatives fail to recognize community-elected leaders or question their authority. Reports of companies attempting to co-opt leaders is also common, leading to internal divisions[73] and undermining the socio-political cohesion and a representativity of Indigenous groups.

Risks to livelihoods and wellbeing

Indigenous peoples are not the only land-linked populations threatened by mining. Extraction also poses more subtle and pervasive effects, especially in regions where subsistence farming and primary dependence on agriculture dominate. In such areas, mining often competes with livelihood-sustaining sectors and degrades critical life-supporting resources. Environmental damage to ecosystems and watersheds caused by mining activities can have severe consequences for subsistence and small-scale farmers, leading to significant setbacks in their livelihoods, and contributing to economic destitution.

Indeed, mining can drive local residents to seek employment within the mining sector as a result of the destruction of traditional livelihoods. In some cases, artisanal and small-scale mining (ASM) may offer an alternative – though often unsafe – source of income compared to agriculture. Reversely, as in the case of the Amazon, illegal small-scale mining is expanding inside protected areas and threating the environment and Indigenous rights. In both cases, when the right opportunities are absent, the lack of necessary skills and competencies can make it difficult for affected populations to find work that is compatible with protecting the sensitive ecosystems around them. These challenges are particularly harmful in fragile settings, where weak governance, the absence of social safety nets, and deep structural development issues exacerbate the situation (see Box 1).

Box 3. **The tensions between agriculture and mining in Democratic Republic of Congo**

In the Democratic Republic of Congo (DRC), the vast majority of the population relies on agriculture activities for their subsistence rather than commercial purposes. In 2020, the agricultural sector accounted for over 20% of the country's GDP and employed more than 64% of the population.[74] By contrast, the mining sector plays a major role in the economy as the main source of export earnings. Manufacturing, however, remains marginal due to a lack of skilled labor and machinery. The DRC is among the five poorest nations in the world, with approximately 73% of its populations – around 60 million people – living on less than U$1.90 a day in 2018.

The Katanga region is particularly rich in minerals, including copper, cobalt, zinc, cassiterite, manganese, coal, silver, cadmium, germanium, gold, uranium, and platinum. The DRC is best known for its cobalt reserves, extracted from the copperbelt within the Katanga region. This area contains a significant number of deposits, making the DRC a central player in the race to critical minerals, as it holds 70% of the world's known cobalt reserves.

In addition, the DRC has the largest artisanal mining workforce in the world, with around two million people involved, but the lack of regulatory controls has resulted in widespread land degradation and pollution.[75] For example, artisanal gold mining in DRC uses approximately 15 tons of mercury annually, making it the second-largest source of mercury emissions in Africa.[76]

The Swiss Glencore, the Chinese COVEC, and the also Chinese mining company Minière de Kalumbwe Myunga (MKM) operate in the Basse Kando reserve, extracting cobalt. In 2015, researchers from Premicongo found that MKM's hydro-metallurgical plant was discharging effluents directly into the Dikanga river, polluting the water and rendering it unsafe for villagers in the surrounding area.[77] Activities such as fishing, irrigating farmland, washing and drinking now pose significant health hazards. Scientific water quality tests revealed that the water is highly mineralised due to industrial activities, with dangerously high concentrations of lead.[78] The contamination makes the water unsuitable for human or animal consumption and for agricultural irrigation. Despite the clear risks, villagers continue to consume the polluted water, as no alternative water source is available. The ongoing health hazards threaten the structural workforce and the long-term development of the area.[79]

The ecological pollution caused by mining also undermines livelihoods, destabilizing existing informal safety nets. In the DRC, subsistence agriculture is a structural necessity, as education is not free and opportunities for unskilled labor in secondary and tertiary sectors are scarce in the country. These barriers make it difficult for individuals to transition from subsistence agriculture to market-oriented agriculture, deepening inequalities between different segments of populations. This creates a negative feedback loop: when mining compromises subsistence livelihoods, vulnerable workers often move into artisanal and small-scale mining (ASM), exposing themselves to hazardous working conditions.

The consequences are often cascading and intergenerational. Families that lose access to subsistence agriculture, or where adults suffer health impairments due to pollution, are less likely to afford schooling for their children. This perpetuates cycles of poverty and vulnerability, further limiting development opportunities.

Artisanal mining creates a development-stunting trap: ASM revenues are insufficient to drive development or compensate for lost livelihood and health hazards. In areas where poverty is widespread, the vulnerable labor force tends to be exploited through abusive pricing by middlemen and industrial companies. Weak or absent state and governance mechanisms fail to mitigate the loss of livelihoods caused by mining, leaving affected communities to fend for themselves. This lack of support fosters conditions for entrenched poverty traps and deepens mistrust in governance institutions. In other words, mining-induced ecological impacts can lead to a direct and logical sequence of human insecurity, localized or widespread development traps, and, in some cases, democratic deficits.

Resource curses and inequalities

The economic trade-offs involved in mining go beyond simple opportunity costs between economic sectors, such as subsistence agriculture. These trade-offs can escalate to macroeconomic levels and transform into what is known as the resource curse. In practice, extractive industries often fail to bring about stability and sustainable development. In fragile countries rich in minerals, there are often fewer constraints on private sector investments and tax obligations. In the best-case scenarios, private companies might invest in infrastructure, corporate social responsibility, and social licenses to operate. However, these investments are rarely aligned with government-sponsored or UN-backed development planning. Instead, they tend to be strategies for generating community engagement while primarily serving the interests of extractive industries. Consequently, in more fragile settings, direct stakeholders – particularly vulnerable communities – often do not reap the benefits of their mineral resources to drive sustainable development.

One of the core characteristics of extractive economies is their limited contribution to long-term economic development. This issue is evident from local to macroeconomic levels. In Brazil, for example, a study by Instituto Escolhas on the social and economic indicators of Amazonian municipalities shows that mining does not provide genuine economic development for local populations.[80]

By comparing mining municipalities with non-mining ones in the same region, the study found that improvements in indicators such as health, education, and GDP per capita are short-lived, disappearing after three to five years. Mineral extraction is the industry that creates the fewest employment opportunities throughout its production chain. Moreover, in the past decade, salaries in the mining sector have declined by an average of 12%. Additionally, the jobs that are generated often follow poor practices regarding workplace health and safety, with mining considered one of the hazardous industries for workers, both mentally and physically, in Brazil.[81]

The mining sector, despite receiving robust government support, often pays limited taxes. As a result, profits are seldom redirected to local communities, which are typically the most affected by extraction activities.[82] In some cases, especially where extraction involves the export of unprocessed minerals, countries can fall into the resource curse[83] – a cycle of dependency on resource exports that leads to economic concentration, fails to redistribute socio-economic benefits, and directs infrastructure expansion toward extraction rather than development.

The gap between economic dividends and social returns is evident in the data. In Brazil, for example, mineral production grew significantly from U$ 24 billion in 2016 to U$ 50 billion in 2023,[84] with mineral extraction activities accounting for about 2.4% of the country's GDP in the same year.[85] However, this economic growth has not been accompanied by a corresponding increase in direct employment or broader indirect benefits. Over the past decade, the mining sector has made only a modest contribution to Brazil's overall national employment. While mining is considered a key driver of the economy, its direct contribution to national employment has remained relatively low compared to other industries. This trend is likely to persist as automation continues to advance, further reducing the sector's contribution to socio-economic gains from mining. In 2023, the mining industry directly employed around 200,000 people, less than 1% of Brazil's total workforce.[86] Conversely, the mining sector has imposed significant social and environmental costs (see Box 4), which tend to endure over time and call into question the overall impacts of mining benefits.

Box 4. **Selected mining impacts in Brazil and economic costs of "externalities"**

Between 2015 and 2020, industrial and small-scale mining deforested more than 40,536 hectares of Amazonian forests. In 2019 and 2020, deforestation caused by mining reached record levels, encroaching into protected and conservation areas. The extent of mining may appear small compared to the main drivers of deforestation (i.e. cattle ranching and industrial agriculture), but nevertheless has far-reaching impacts, including at the periphery of protected areas and Indigenous territories. Both industrial and small-scale mining has also led to conflict and violence in the Amazon, including within Indigenous territories.

Outside the Amazon, in other traditional mining regions in Brazil like Minas Gerais, mining companies such as BHP, Vale and Sarmaco contributed to some of the largest socio-environmental disasters in Brazil's history, particularly in Mariana and Brumadinho. The collapse of tailings basins caused hundreds of deaths and consequential impacts on local ecosystems and affected communities. Indeed, the effects of these disasters on the Doce and Paraopebas Rivers were so devastating that nearby communities reported the two rivers essentially "died."[87]

The impacts of large-scale industrial mining on communities are significant. For example, quilombola communities (AfroBrazilian communities made up of the descendants of slaves and designated as traditional peoples within Brazilian legislation) along the Trombetas River in Pará state, have coexisted for four decades with bauxite (aluminum) mining and the successive loss of waterways contaminated by mining waste while being vulnerable to the largest complex of tailing dams in the Amazon.[88]

There is also significant small-scale mining (*garimpo*) that generates extensive damage to ecosystems and local populations. Contamination related to mercury, one of the substances used to extract gold, has already reached alarming levels in Amazon rivers like the Tapajós and the Uraricoera, compromising the health of Indigenous peoples and riverside dwellers. Various communities living near such *garimpo* areas have initiated protests against such contamination.

Meanwhile, environmental defenders seeking to resist illegal mining are facing rising threats. A report by Global Witness on environmental activists in 2021 found that of the 227 defenders assassinated the previous year, 17 were killed as a result of conflicts related to mining. Indeed, mining is considered one of the most lethal sectors for activists globally, alongside logging, dam building, and agribusiness. Latin American communities are disproportionately impacted, with almost 75% of all the murders recorded in the world. Brazil ranks fourth overall, with 20 deaths of environmental defenders in 2020.[89]

The tax implications of critical raw material (CRM) mining require scrutiny, particularly regarding tax negotiations and fiscal evasion in fragile contexts. Taxation is the primary mechanism through which host countries can derive significant benefit from extractive industries, provided it is structured to support genuine socio-economic redistribution. However, one of the greatest paradoxes for host countries lies in the concessions they must offer to attract investments through favorable taxation systems.

Developing countries often face substantial deficits in transportation, industrial and energy infrastructure, as well as in educational and technical capacities. Yet mining is a sector heavily reliant on infrastructure, technology, energy, and skilled labor. This mismatch frequently leads private sector actors to argue for reduced taxation and royalty rates, claiming they must shoulder the costs of infrastructure, energy and technology investments as part of their business model to operate in these countries. However, the infrastructure developed by mining companies is often focused on extraction activities, with poor integration into national development plans. As a result, these investments rarely contribute to long-term synergistic co-benefits, such as improved transportation networks, local energy accessibility, or sustainable development initiatives.

The mining sector is not only associated with low tax rates but is also highly susceptible to tax evasion. In many developing countries large-scale mining operations are predominantly conducted by foreign-owned multinational companies. And governments often lack the capacity to tackle complex tax avoidance techniques. According to 2019 United Nations study,[90] the amount defrauded by mining companies operating in Africa exceeds the continents' total annual foreign direct investment.

A 2021 International Monetary Fund (IMF) paper estimated that mining profits in sub-Saharan Africa are notably vulnerable to profit shifting compared to other sectors. The report estimated the fiscal cost of tax avoidance in mining at between U$450 and U$730 million per year for the region.[91] Many sub-Saharan African countries lack tax legislation that is adequately equipped to address the challenges of ensuring fair fiscal contributions from the sector. International frameworks and cooperation to tackle tax avoidance, particularly in jurisdictions where companies are headquartered, remain insufficient.

These issues are likely intensified by the global race for critical minerals. Resource nationalism is on the rise in Global South countries, driven by competition among geopolitical heavyweights and of industrial protectionism in developed countries. At the moment, Global South countries are competing against one another to attract resource investments. This competition has spurred a race to the bottom in corporate tax policies, including tax reductions, exemptions, and tax holidays. Such tax competition often creates negative spillover effects, pressuring other countries to adopt similar measures. The outcome is detrimental: all countries lose,[92] development is stifled, and mining fails to deliver long-term economic benefits.

This scenario may shift depending on the ability of Global South countries to negotiate support and investments for creating industrial ecosystems around extraction that promote economic diversification within fair and green economies. This includes establishing legal and policy frameworks and tools to ensure environmental responsibility, social equity, and economic sustainability (such as sovereign funds, green industrial policies, local capacity and capability development mechanisms, and many more).

This approach could change the historical patterns of underdevelopment, especially as countries face escalating climate-related disasters. The combination of extractive activities and climate vulnerability is poised to generate severe long-term repercussions. Yet, the combination of climate change and mining-related risks are rarely discussed in the grand bargains between Global North and Global South countries concerning supply chains.

Section IV. Geopolitical dynamics and drivers

Critical minerals are not just key for today's energy, digital and military supply chains. They underpin climate security and the race for technological innovation, serving as backbone of both soft and hard power that will redefine the balance of global dynamics for decades. As such, they are the locus of intense competition. While this competition does not have to be a zero sum game, significant imbalances in this critical climate action decade amplify geopolitical risks and intensify a scramble toward mineral-rich countries and ecosystems. These security dilemmas surrounding critical minerals escalate ecological, governance and economic vulnerabilities in Global South countries.

Supply chain efficiency is a winning factor in this competitive landscape. Through sustained investments since the mid-1990s, China has achieved exceptional cost and knowledge transfer efficiency in integrating mining with processing and beyond.[93] It has perfected an industrial-technological policy model built on vertically integrated rare earths supply chains – including mining, processing, refining, and assembly – which it later extended to other types of minerals.[94] This approach has created economies of scale that are challenging for competitors to match. Vertical integration and the industrial expertise required to refine and innovate mineral chemistry takes decades to develop. China's first mover advantage has positioned it as a leader in a race that will shape future geo-economic and geopolitical power dynamics, as well as governance and security frameworks.

The full effects of China's vertical integration are now evident in its so-called overcapacity.[95] China is the leading global producer of solar panels, electric vehicles, hydroelectric dams and potentially, in the near future, wind turbines.[96] This massive production capacity not only drives the rapid deployment of clean tech deployment domestically but also boosts its export capacity. The implications for global markets are complex.[97] On one hand, Chinese production capabilities makes it the primary provider of global public goods in terms of climate mitigation. Its role is absolutely essential in this critical climate decade for accelerating progress towards net-zero goals. On the other hand, Chinese overcapacity is dampening international competition, which is vital for maintaining political and economic balances in key technological sectors across the Global North and South. The competitiveness of Chinese exports poses severe challenges for clean tech companies in the West and other regions. As a result, protectionism[98] and resource nationalism[99] are on the rise in both the Global North and South. Ironically, Chinese overcapacity could ultimately slow the pace of the energy transition, even as the years 2023-2024[100] clearly demonstrate the alarming acceleration of global warming.

China's industrial scale effects extend beyond international markets to influence international relations and investments, raising questions about how China leverages mineral investments and the global energy transition to strengthen its geopolitical position. Initially driven by the need for economic development and the surging global demand for material, China expanded its economies of scale to include extractive investments abroad whilst keeping processing and technological development investments firmly in the domestic realm.

As part of its Belt and Road Initiative (BRI) and related geo-economic projects,[101] China has strategically invested in geological survey capacity, exploration and extraction worldwide. These mineral investments have contributed to expand China's geo-economic reach, fostering forms of soft power and creating long-term dependencies. This is particularly evident in certain regions of the Global South, including in the so-called "lithium triangle" in the salt flats of Bolivia, Chile, and Argentina, where nations tend to compete against each other for mining revenues.[102]

To be clear, the BRI has delivered many benefits for countries in the Global South, particularly in terms of infrastructure and economic growth. However, concerns persist regarding new forms of economic vulnerability and dependency associated with BRI and other Chinese foreign investments, including structural technological and digital dependencies[103] that may pose security risks in the future. In an increasingly multipolar world, where countries in the South are central to the global narratives and normative competition,[104] China holds a comparative advantage through its investments in economic relationships that are essential for bargaining power today.[105]

Beyond China's growing influence in the Global South, its ability to dampen international competition in world markets has also been a defining factor. However, the primary trigger of geopolitical and geo-economic tensions over the last decade has been China's ability to instrumentalise supply chains for its own benefit, often to the detriment of technology-intensive countries in the Global North. Over the last three decades, these countries have developed structural dependencies on China for the supply of processed minerals.

Currently, EU countries remain 60 to 100% dependent on China for various supply chains, including rare earths, gallium, germanium, and manganese.[106] The United States also registers high levels of dependency on China for key industrial materials.[107] In the last decade, China has either implemented or threatened export restrictions and mineral quotas in disputes with Japan, Australia, the US, and the EU.[108] Such actions can create critical bottlenecks for technology-intensive industries, leading to slowdowns and contractions in affected economies.

As a result, mineral supply chains have become a focal point of high security concern for Western economies, prompting these countries to secure access to diversified mineral deposits, processing capabilities, and technological innovation. While the United States aims to decouple from China across various supply chains, the European Union seeks to de-risk its dependence on both China and Russia. Achieving these goals requires diversification of assets and resource extraction strategies, placing Global South countries at the center of these efforts. Consequently, a new era of raw materials diplomacy between Global North and Global South countries is emerging.[109] This shift presents a tremendous opportunity for economic growth, diversification, and advancements in climate finance, adaptation research, technology transfers and the promotion of a multipolar balance of power.

This growing interest in resources located in Global South countries carries risks if industrial diplomacy fails to address ecological, governance, and conflict sensitivities. Should geo-economic and geopolitical dilemmas drive industrial diplomacy at the expense of climate, ecological and governance considerations, a new scramble for resources may unfold, leading to zero-sum competition. Such an outcome could leave Global South countries vulnerable to incoherent development strategies, climate maladaptation, and ecological collapse. Given that these nations host critical ecosystems and biodiversity hotspots, the repercussions would extend globally, exacerbating climate change and biodiversity loss, ultimately endangering planetary stability.

In other words, extraction and potential processing investments in Global South countries must account for ecological integrity, climate vulnerability, and governance fragilities to ensure they result in long-term economic and socio-political gains, rather than skewed rentier economies, and enduring ecological and socio-economic costs. Achieving this requires more than transactional diplomacy. It demands integrating raw materials diplomacy with initiatives in climate and nature finance, adaptive development research hubs, trade diversification, inclusive and sustainable development, governance capacity building, and, in some cases, conflict resolution. For Global North countries seeking to de-risk supply chains and reduce vulnerability to geo-economic and geopolitical instrumentalization, multi-dimensional diplomacy is essential. This approach should prioritize co-designing collective security frameworks with Global South countries that are not arbiters of the global energy transition but also pivotal players in the global balance of power.[110]

Countries of the Global South are right to demand that the de-risking agenda align with their objectives – ideally going beyond a narrow focus on economic diversification. They require support to establish coherent and sustainable industrial hubs while simultaneously investing in ecological regeneration, natural resource management, energy expansion, and trade diversification. However, these priorities are largely absent from most strategic announcements regarding critical minerals or plans to accelerate the global energy transition. One reason for this disconnect is that industrial policies are often decoupled from the broader planetary security stakes during this make-or-break decade for the climate. Addressing international security concerns is vital, as is the need to build a governance system for planetary security that integrates CRM supply chains with robust governance frameworks.

Conclusions

Critical minerals offer valuable insights into the state of international security and the health of the planet, particularly in the context of the multidimensional energy transition. The race to secure critical mineral supply chains is reshaping political and economic relationships while driving the restructuring of governance systems both within and between countries. This energy transition is not isolated – it forms part of a much broader transformation of sustainable development, international peace and security architectures that will influence the stability of countries and the global climate.

A collective approach to designing the fair and green energy transition – specifically the extraction, processing, and application of critical minerals – is essential for ensuring its legitimacy, credibility, and sustainability. Without effective management, the world's most ambitious and urgent industrial revolution risks being compromised.

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1. This paper was written by Olivia Lazard, director of Peace in Design Consulting, TED Speaker and fellow at the University of Exeter and Carnegie Europe. It received the inputs and editorial support from Laura Trajber Waisbich, Giovanna Kuele, Lycia Brasil, Robert Muggah and Debora Chaves at the Igarapé Institute.

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