

Critical Minerals, Water Insecurity and Injustice



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UNU-INWEH specializes in addressing critical global security and development challenges at the intersection of water, environment, and health. Through research, capacity development, policy engagement, and knowledge dissemination, the institute bridges the gap between scientific evidence and the practical needs of policymakers and UN member states, with particular attention to low- and middle-income countries. By collaborating with a diverse array of partners—including UN agencies, governments, academia, the private sector, and civil society—UNU-INWEH develops solutions that advance human security, resilience, and sustainability worldwide.

Critical Minerals, Water Insecurity and Injustice

United Nations University Institute for Water, Environment, and Health (UNU-INWEH)
Richmond Hill, Ontario, Canada, 2026

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Front cover image: Children display their copper catch during Fairphone's first factfinding mission in the Democratic Republic of Congo; photo via Flickr.



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Glossary of Abbreviations

CM	Critical Minerals
EVs	Electric Vehicles
WASH	Water, Sanitation and Hygiene
DRC	Democratic Republic of the Congo
FPIC	Free, Prior and Informed Consent
SDGs	Sustainable Development Goals

Executive Summary



Rare-earth oxide samples: praseodymium, cerium, lanthanum, neodymium, samarium, gadolinium. Photo by Peggy Greb/US-DA-ARS.imagery, 8 March 2024. Image processed by UNU-INWEH.

The global energy, digital, and sustainability transitions have significantly increased the demand for critical minerals, which are essential for the development and operation of artificial intelligence (AI), renewable energy technologies, and clean transportation systems. Projections suggest that this demand will quadruple by 2050 if current consumption patterns and extractive policies remain unchanged. Specifically, the demand for lithium, graphite, and cobalt could increase by approximately 500% by 2050. This prevailing extractive trajectory is marked by serious environmental and social injustices that are often overlooked or obscured by dominant economic, political and even sustainability transition narratives.

This report by the United Nations University Institute for Water, Environment and Health (UNU-INWEH) on its 30th anniversary presents a comprehensive analysis of the fundamental contradictions at the heart of this global transition with a special focus on the water sector. The report discusses how the accelerated pursuit of critical minerals is directly contributing to acute water insecurity, livelihood disruptions, and health risks in many of the world's most vulnerable regions. It further highlights how disparities in environmental and health outcomes expose structural inequalities, revealing who benefits from, and who bears the costs of, the global energy, digital, and sustainability transitions. Leveraging empirical analyses, scientific studies, policy documents, and media reports, this report synthesizes evidence on the extraction of critical minerals from both Global North and South, specifically drawing on data from the Lithium Triangle, the Democratic Republic of the Congo (DRC), and other high-risk regions.

The extraction of critical minerals significantly exacerbates water insecurity, primarily through excessive freshwater use and the contamination of local water

sources. This not only threatens access to safe water for nearby communities but also undermines agricultural livelihoods and food production, particularly in regions already facing water scarcity. Mining operations frequently discharge effluents containing toxic chemicals into rivers and streams, degrading water quality and reducing availability. Such pollution directly violates the fundamental human right to safe water and disrupts water-dependent livelihoods, including farming, fishing, and livestock rearing, further limiting household access to clean drinking water.

The health risks associated with mining-related water contamination are especially severe in communities located near extraction sites. Evidence from regions such as South Africa's Limpopo Province, Bolivia's Uyuni region and the DRC reveals widespread heavy metal contamination and toxic waste exposure. These environmental hazards have led to serious health problems, particularly among women and children, including reproductive harm, birth defects, and chronic illnesses.



Creuseurs working at a Gécamines copper-cobalt site in Kolwezi, DRC. Photo by Fairphone/Flickr.

Two Realities: Comparing the Costs and Benefits of Critical Mineral Extraction

Extraction Zones (Costs)	Consumption Hubs (Benefits)
 Economic Costs <ul style="list-style-type: none"> • Loss of livelihoods • Poverty and economic deprivation • Unfair benefits sharing 	 Economic Benefits <ul style="list-style-type: none"> • Energy security and industrial growth • Job creation • Technological advancement
 Social Costs <ul style="list-style-type: none"> • Community displacement and dispossession • Child labour exploitation and gender inequality • Social conflict and instability 	 Social Benefits <ul style="list-style-type: none"> • Enhanced national security and stability • Technological empowerment • Education and workforce development
 Environmental Costs <ul style="list-style-type: none"> • Water insecurity • Pollution and environmental degradation • Climate vulnerability 	 Environmental Benefits <ul style="list-style-type: none"> • Clean energy • Reduced pollution and emissions • Preserved local ecosystems
 Health Costs <ul style="list-style-type: none"> • Fragile health infrastructure • Poor population health • Violence and community health crisis 	 Health Benefits <ul style="list-style-type: none"> • Advanced medical equipment and devices • Enhanced living and health conditions • Healthy communities and neighborhoods

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Figure 1. Distribution of costs and benefits of critical minerals extraction between extraction and consumption zones: The economic and environmental gains of highly industrialized nations are often sustained by social and ecological injustices in resource extraction zones across the Global South. This highlights a paradox showing how the sustainability of developed countries is effectively subsidized by systemic harms inflicted on developing nations and marginalized communities.

The report argues that the extractive industry for critical minerals is marked by deep structural injustices and global inequalities. Most extraction occurs in the Global South, where local communities disproportionately bear the environmental degradation, and livelihood disruptions associated with mining activities. In contrast, the economic, technological, environmental, and health benefits of these minerals largely accrue to wealthy nations, communities and individuals, mostly in the Global North. This imbalance raises a pressing question: Does the global race for critical minerals represent a new form of extractive colonialism, replicating the injustices of the fossil fuel era under the banner of sustainability?

The evidence from this investigation suggests that without deliberate policy intervention, the current trajectory of mineral extraction risks entrenching existing inequalities and further harming vulnerable communities. This report therefore underscores the urgent need to protect water resources from the harmful impacts of mineral extraction. Governments must adopt and uphold robust environmental policies, including strict enforcement of environmental laws, regular public testing for pollutants, rehabilitation of degraded lands and ecosystems, and integration of Indigenous and local knowledge into environmental management to promote sustainable extraction and ecosystem restoration. Effective implementation will depend on institutional capacity, cross-sector collaboration, and dedicated funding for long-term environmental recovery.

To address the hidden trade-offs in critical mineral supply chains, global governance systems must be strengthened. This includes establishing mandatory international standards for due diligence to replace voluntary compliance, promoting North–South policy coordination and legally binding mechanisms for ethical

sourcing and environmental justice, and enforcing strict pollution and wastewater controls, including zero-discharge systems, requiring independent monitoring of water use, waste management, and heavy metal contamination. It is also important to ensure regular public disclosure of environmental data to enhance transparency and accountability.

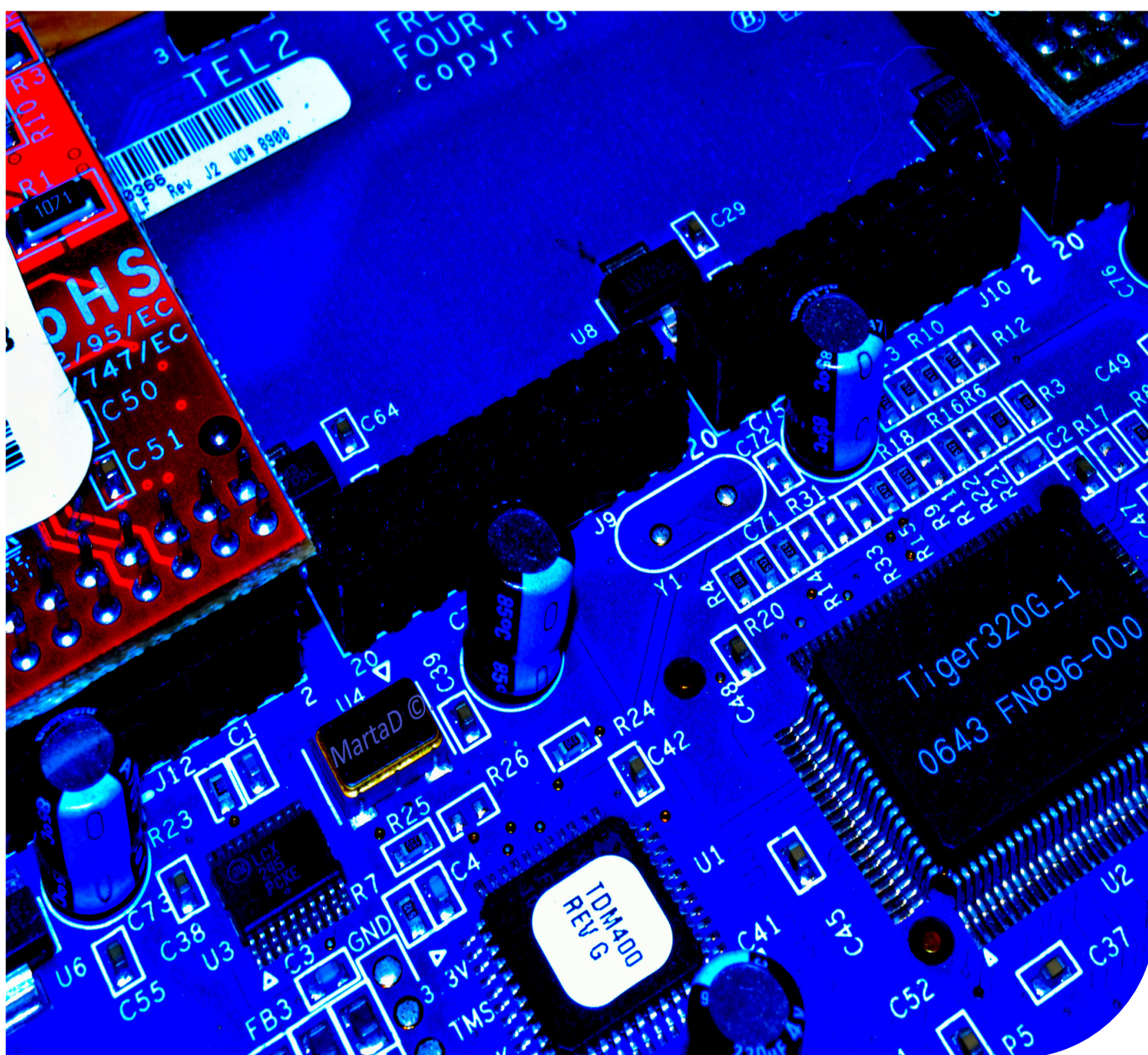
Additionally, a circular economy framework is essential to conserve finite resources and reduce the environmental and social harms of large-scale mining. Governments and international partners should invest in research, innovation, and technology for material substitution, waste mitigation, and sustainable product design. Furthermore, they need to develop advanced recycling systems for batteries, electronics, and renewable energy components, support industries that repurpose waste materials, and create incentives for companies to design products with longer life cycles and greater recyclability.



Tesla parked in Jaffa, Tel Aviv, an electric vehicle built with critical minerals such as lithium, cobalt, and nickel. Photo by LeRenartQuiPense/Wikimedia Commons.

Addressing the impacts of critical mineral supply chains on water resources, health, and livelihoods across diverse socio-economic and geographic contexts requires informing – the aim of this report – and engaging a broad spectrum of stakeholders, including international organizations, governments, civil society, media, and academia. There is a critical need to develop and implement comprehensive strategies that address the hidden trade-offs of global energy, digital, and sustainability transitions, while promoting equitable and inclusive supply chain systems that support sustainable water management and

fair resource governance, particularly in regions experiencing increased resource extraction. Addressing these environmental injustices is essential to achieving the UN Sustainable Development Goals (SDGs), particularly SDG 6 (Clean water and sanitation), SDG 3 (Good health and well-being), SDG 1 (No Poverty), SDG 7 (Affordable and clean energy), and SDG 10 (Reduced inequalities). Overall, this UNU-INWEH report calls for urgent and inclusive policy action to ensure that the global transition to sustainability is not achieved at the expense of those least equipped to bear its costs.



Semiconductor chip created through photolithography, a process reliant on critical minerals. Photo by Marta Diago Marco/Flickr.

Key Findings

To meet global climate targets, demand for key critical minerals (e.g., lithium, graphite, cobalt) is projected to quadruple by 2050.

Global reserves for critical minerals are concentrated in vulnerable regions with about 16% in high water stress regions and 54% of energy transition minerals on or near indigenous territories.

The extraction of critical minerals is water-intensive and about 1.9 of million litres of water is needed to produce just a tonne of lithium in some areas.

In 2024, global lithium output was about 240,000 tons, demanding an estimated 456 billion liters of water, equivalent to the annual domestic water needs of 62 million people in sub-Saharan Africa.

For every ton of rare earth minerals produced, about 2,000 tons of toxic waste are generated.

In 2024, global rare earth production is estimated to have produced about 707 million metric tons of toxic waste, equivalent to nearly 59 million loaded garbage trucks.

Critical minerals extraction intensifies water insecurity by depleting freshwater sources, polluting existing supplies, and undermining people's capability to access safe water.

In regions like Chile's Salar de Atacama, lithium and other mining accounts for up to 65% of regional water usage, intensifying competition with agriculture and domestic needs leading to dramatic groundwater depletion.

In major critical minerals producing nations like the DRC (Cobalt), over 80% of mineral output is controlled by foreign industrial mines, limiting local economic gains and value-addition.

Despite the vast mineral wealth, 73.5% of the population in the DRC lives on less than \$2.15 a day, highlighting a stark local economic disparity.

Extraction of critical minerals contributes to water pollution and freshwater depletion, posing serious health risks disproportionately affecting women and children.

Empirical studies show that 72% of respondents near mining sites in the DRC reported skin diseases, and 56% of women and girls reported gynecological issues, demonstrating the disproportionate health burden.

In DRC, neural tube defects, lower limb defects, cleft lip, and abdominal wall defects have been higher in maternal wards located near mining areas compared to those situated farther away.

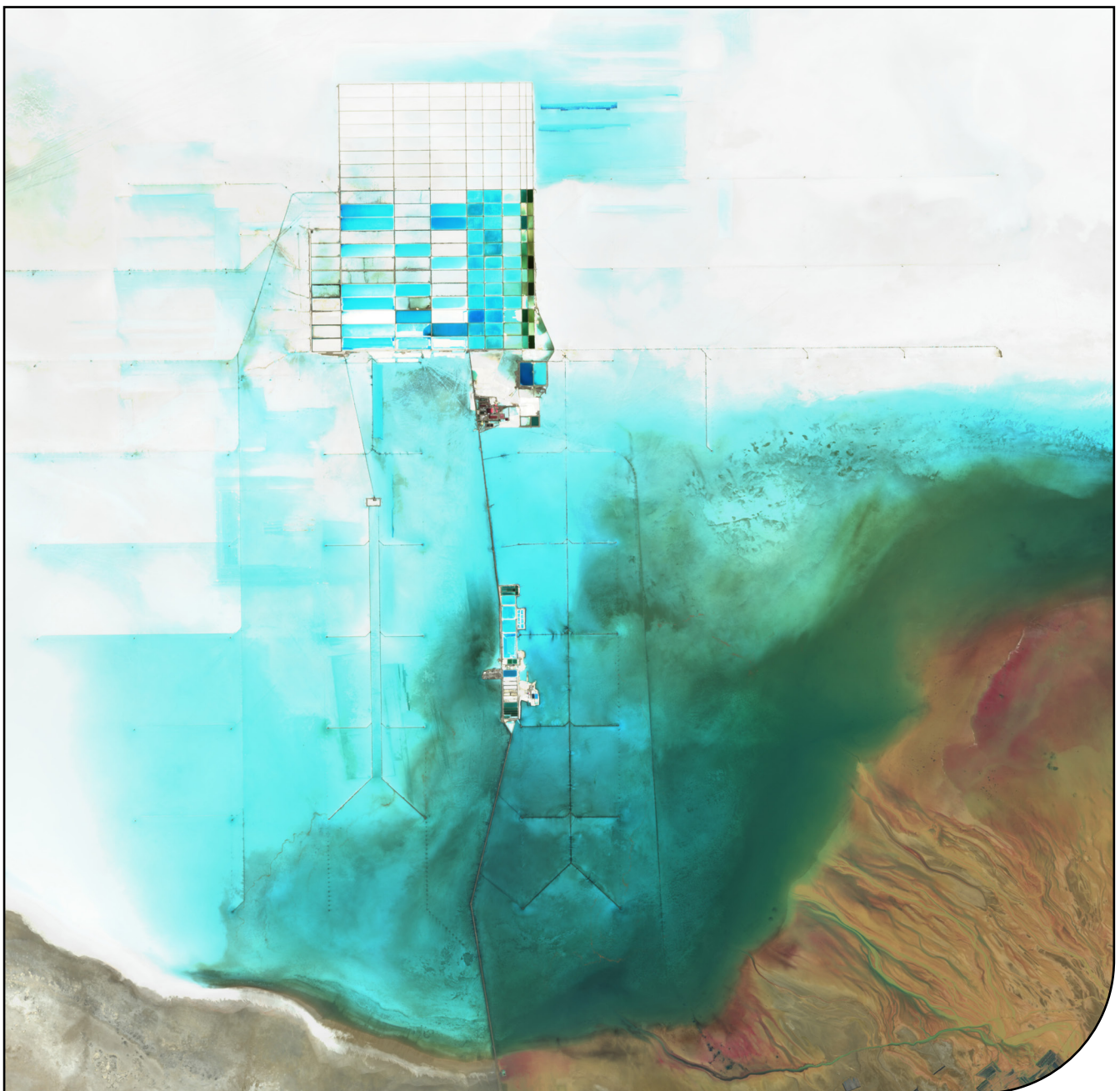
In communities close to DRC's mining areas, neural tube defects are occurring at a rate of 10.9 per 10,000 births, followed by lower limb defects at 8.8 per 10,000 births.

About 30% of mining sites in the DRC employ children, who often lack basic health and safety protections.

The lack of global governance model for critical minerals undermines progress toward the sustainable development goals (SDGs).

The social and environmental costs of extracting critical minerals are often borne by marginalized communities in the Global South, while the technological, economic, environmental and health benefits primarily accrue to industrialized nations and their populations.

1. Critical Minerals: The Oil of the 21st Century



Evaporation ponds for lithium extraction in the Salar de Uyuni, Bolivia. Sentinel-2 false-color imagery, 8 March 2024. Image processed by UNU-INWEH.

The world is currently experiencing two interconnected transitions. The first is a widespread technological transformation that involves integrating digital technologies, such as Artificial Intelligence (AI), clean energy solutions (including solar panels, wind turbines, battery storage, hydrogen electrolyzers, and fuel cells), and electric vehicles (EVs). The second transition is a shift toward net-zero economies, often referred to as the green transition. Both transitions are linked, as advancements in digital technologies can pave the way for the green transition by helping to reduce greenhouse gas emissions.

These transitions along with the continuous development of modern military infrastructure and defence systems rely on critical minerals and have intensified their demand. Critical minerals, which include cobalt (Co), copper (Cu), lithium (Li), cadmium (Cd), and some rare earth elements (REEs), are non-fuel minerals or metals vital to the functioning of modern technologies such as AI, EVs, solar panels, and wind turbines, among others.^{1,2} Critical minerals are essential for economic and national security, serving as the oil of the 21st

century, i.e., the fuel of the Fourth Industrial Revolution (Industry 4.0). They are what make EV batteries small yet powerful enough for longer driving ranges; they make it possible for the development and functionality of AI, and they are indispensable for maximizing the performance and durability of smartphones and laptops. These are just a few of the many technologies that rely on critical minerals.

The demand for critical minerals tripled between 2010 and 2023 with lithium,³ for example, recording a 30% increase in demand in 2022 alone, while cobalt and nickel demand grew by 70% and 40%, respectively, from 2017 to 2022.^{3,4} This trend is expected to continue with demand for all critical minerals projected to increase sharply to more than double by 2030 and quadrupled by 2050.^{4,5} Between 2000 and 2022, the total market size for critical minerals more than doubled, reaching over USD 320 billion in trade value.³ Projections suggest that demand for graphite, lithium, and cobalt could rise by nearly 500% by 2050, compared to 2020 levels, if the world is to meet the carbon budgets of 1.5°C or 2.0°C.⁶



A data center in Virginia, illustrating how modern digital infrastructure depends on critical minerals used in servers, cooling systems, and power equipment. Photo by Christopher Bowns / Flickr / Wikimedia Commons.

Critical Minerals and Their Roles in Energy Transition and Technology

Li Lithium Used in batteries for electric vehicles and large scale grid storage, also in medicine and nuclear reactors	Co Cobalt Helps stabilize batteries and is used in strong metal alloys, magnets, and industrial catalysts	Ni Nickel Important for stainless steel and hydrogen fuel cells	C Graphite Used in battery anodes, lubricants, fuel cells, and nuclear reactors	Mn Manganese Strengthens steel and improves battery cathodes
Nd Neodymium Creates powerful magnets for electric vehicle motors and lasers	Dy Dysprosium Improves magnet durability and is used in nuclear reactors	Pr Praseodymium Used in magnets, glass coloring, and metal alloys	Tb Terbium Used in lighting materials and high performance magnets	Cu Copper Essential for electrical wiring, motors, and renewable power grids
Pt Platinum Catalyst for fuel cells, electronics, and automotive technologies	Ga Gallium Important for semiconductors and solar panels	In Indium Used in touchscreens and solar coatings	Sn Tin Used in soldering and electronics	Zn Zinc Protects steel through galvanization and is used in batteries
V Vanadium Used in flow batteries and strong metal alloys	Ag Silver Important for solar panels and electronics	Al Aluminum (from Bauxite) Lightweight metal used in buildings, transport, and power transmission	Cr Chromium Strengthens stainless steel and turbine alloys	Si Silicon Core material for computer chips and solar cells

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Figure 2. Critical minerals and their functional roles in energy transition and advanced technologies, as classified according to the U.S. Geological Survey's 2025 Critical Minerals List.⁷



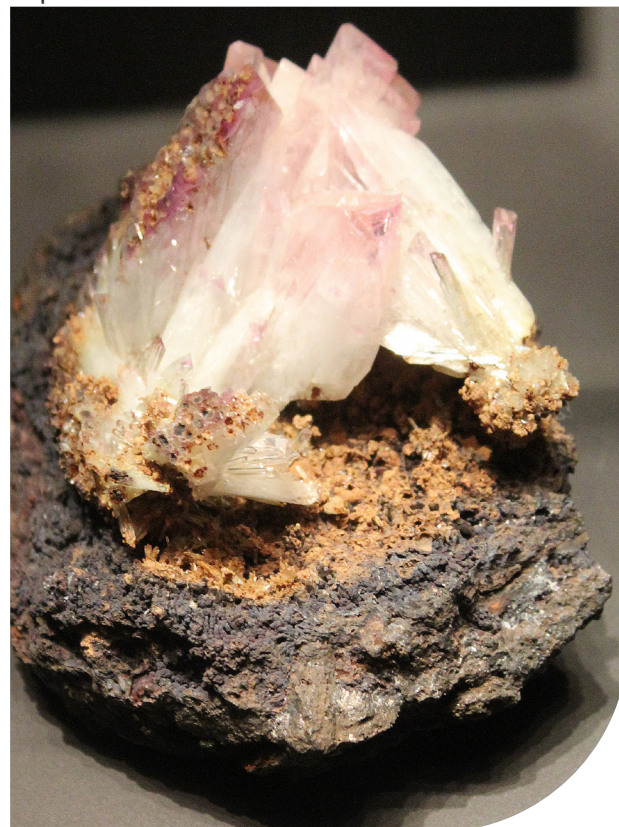
Wind turbines at a wind farm, which rely on critical minerals for key components. Photo by Winchell Joshua.

However, this surge in demand for rare earth minerals has a major hidden cost.⁸⁻¹³ While critical mineral can be found in many countries across the world, most of these minerals are extracted in parts of the Global South, where extraction often comes at a great social and environmental expense.^{8-10,14-19} Mining communities across the globe have faced environmental degradation, health problems, and unsafe or exploitative working conditions.^{2,19-22}

Meanwhile, the benefits of the green and digital transitions (the advanced technologies and economic gains) are mostly reaped elsewhere by wealthier nations and consumers, mostly in the Global North. This imbalance between who benefits and who bears the burdens is raising serious concerns about whether the world's digital revolution and transition to sustainability is just and fair. A problem is thereby posed which has become augmented in the light of the injustices associated with the past human experiences with oil and fossil fuel extraction in developing countries: Could the global rush to extract critical minerals be a reproduction of the neoliberal extractive colonialism which is worsening pre-existing inequalities and injustices in the Global South? In other words, can it be argued that in its rush toward sustainability, the world is employing a set of policy and economic tools that facilitate deregulation, privatization, and extraction of natural resources, labor, and wealth from less developed regions for the benefit of more

powerful nations or corporations with the "sustainability transition" justification?^{23,24}

The extraction of critical minerals contributes directly to the depletion and contamination of freshwater sources, thereby jeopardizing local livelihoods that depend on these resources and creating considerable public health risks.²⁵⁻²⁷ Yet, the extractive operations of these critical minerals are concentrated in contexts where about a billion people still lack access to basic drinking water, a significant threat to population health and wellbeing. The anticipated increase in demand for critical minerals will place additional pressure on local freshwater resources in mining regions and exacerbate existing water struggles among local populations, including the farming communities who rely on scarce water resources for their food and income. This has created a significant, but neglected trade-off and injustice, where the global transition to sustainability in the digital age costs the health and well-being of highly vulnerable communities and groups in certain parts of the world. While some aspects of this injustice along the critical minerals supply chain have received the attention of academics and media, the water, health and sanitations aspects remain overlooked.



Cobaltian adamite specimen from Mapimí, Mexico. Photo by Dguendel/Wikimedia Commons.



Workers installing solar panels. These panels incorporate critical minerals. Photo by Oregon Department of Transportation.

Observers also note that the clean-energy boom could mirror past injustices seen in industries like oil extraction, creating new examples of inequity.^{1,11,28} Past experiences of modern humans prove that the fossil fuel economy is rooted in histories of oppression, dispossession, and marginalization of low-income countries and poor communities through neoliberal extractive colonialism.^{5,11,29} More specifically, in the fossil fuel era, some resource-rich areas became “sacrifice zones” or the places heavily polluted and harmed for the sake of economic progress of other regions, nations, and groups that are normally wealthier and more privileged.²⁹ Without corrective action, the rush for critical minerals might generate new sacrifice zones, particularly in the Global South, with vulnerable communities again paying the price for global advancement.

For instance, the Democratic Republic of the Congo's (DRC) cobalt and copper mining region is described as a zone where populations suffer devastating health consequences and human rights abuses due to living in heavily contaminated areas.^{8-10,17} There are also reports of labour conditions such as child labour and forced work, underscoring the urgency of the issue.^{9,30-33} Estimates suggest that about 30% of sites in DRC employ children, who often lack fundamental health and safety protections.³⁰ Working conditions in mines can be unsafe, exposing women to higher risks of gender-based violence.⁸

This report of the United Nations University

Institute for Water, Environment and Health (UNU-INWEH), on its 30th anniversary, examines the nexus between critical mineral mining and water insecurity, highlighting the injustices embedded in the global energy, digital and sustainability transitions, particularly the unequal distribution of its benefits and burdens. While the pressing environmental problems of humanity, including climate change, rightly captures global attention, it is essential not to overlook the new impacts and dynamics introduced by the mitigation solutions. The extraction of resources needed to support the global energy, digital and sustainability transitions, although crucial for combating a range of socio-economic and environmental problems and existential threats to humanity, brings its own local socio-economic and environmental consequences. The urgency of policy action and the potential severity of the consequences of business-as-usual often obscure the critical need to address these local effects. Therefore, a comprehensive and balanced approach is necessary to ensure that our solutions do not unintentionally create new environmental,



Wolframite ore shown by an artisanal miner in Kailo, DRC (October 2007). Photo by Julien Harneis/Flickr.

health, socio-economic, and political burdens.

The key questions addressed by this UNU-INWEH report are: a) Who suffers in the global push for sustainability transition that is based on increased and rapid extraction of critical minerals?; b) How can we ensure that the benefits and burdens of the global rush for extraction of critical minerals are distributed equitably across the globe? The report explores these questions with a particular focus on the connections between water security in the communities and regions affected by critical minerals extraction. Water security in this report refers to “the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socioeconomic development, for ensuring protection against waterborne pollution and water related disasters, and for preserving ecosystems in a climate of peace and political stability”^{34,35}

It is important to acknowledge that the injustices and inequalities resulting from the extraction of resources, including critical minerals are not entirely new. Yet they have been amplified considerably in recent times due to the geo-political, security and national interests in critical minerals. While the report takes a global perspective, the majority of empirical examples are drawn from the Global South, where most unregulated and unmonitored critical mineral mining activities are concentrated.



A vertical view of Bayan Obo, the world's largest rare earth deposit, Inner Mongolia, China. Processed by UNU-INWEH using Sentinel-2 imagery.



Washing copper ore, Kolwezi, DRC. Photo by Fairphone/Flickr.

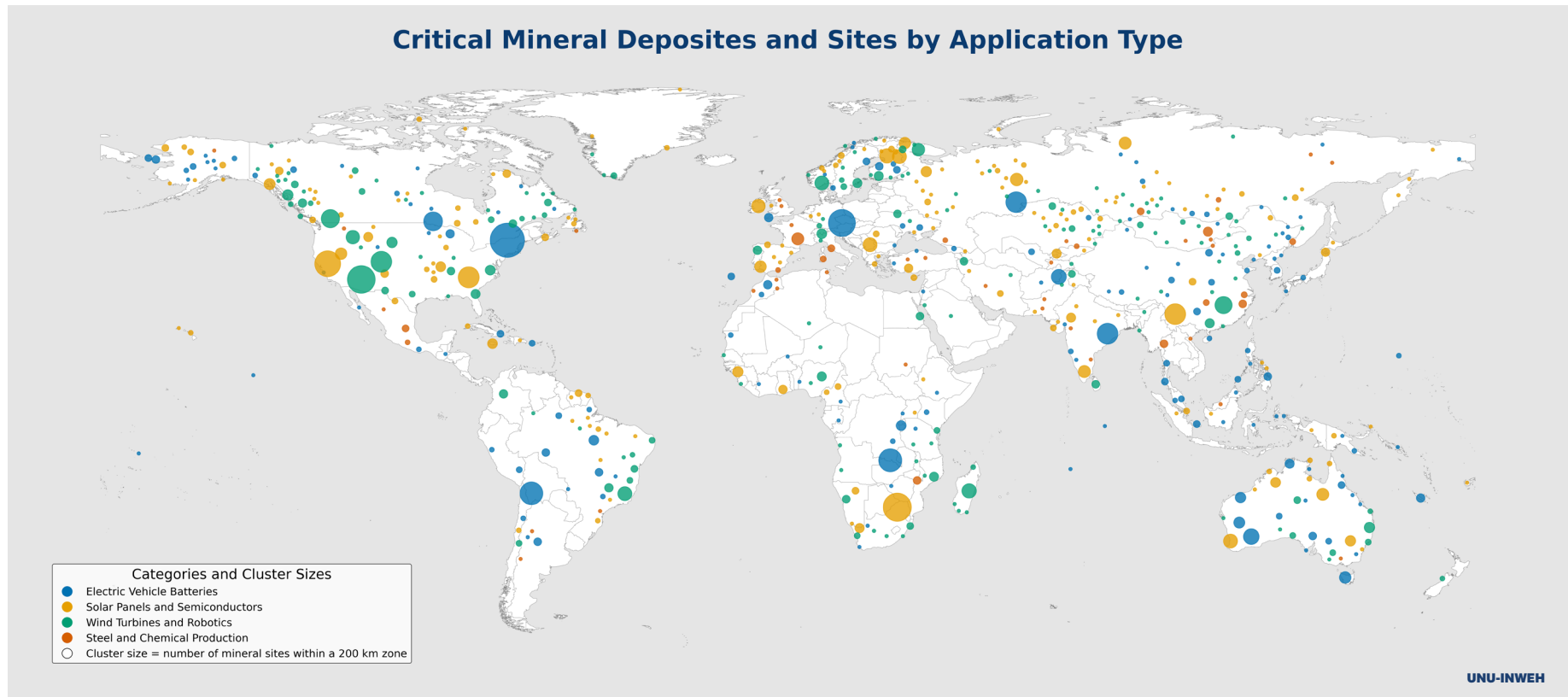


Figure 3. Global clusters of critical mineral deposits and sites, derived from USGS geospatial point data on mines, deposits, districts, and mineral regions (2017). The map identifies areas where multiple deposits occur within a 500-kilometre radius and illustrates the spatial distribution of minerals essential for key technologies: electric vehicle batteries (lithium, cobalt, manganese, graphite, tin); solar panels and semiconductors (gallium, germanium, indium, tellurium, platinum-group elements); wind turbines and robotics (rare-earth elements, niobium, tantalum, titanium, zirconium, hafnium, vanadium, beryllium, rhenium); and steel and chemical production (fluorite, barite, antimony).^{36,37}

2. Critical Minerals Across the Globe



Old open-pit mine and nearby Gécamines facilities, Kolwezi, DRC. Photo by Fairphone/Flickr.

Critical minerals have two distinct characteristics: 1) they are non-fuel minerals vital to the functioning of modern technologies, economies, or national security, and 2) they have supply chains that are susceptible to disruption.² Thus, the term ‘critical’ is used to describe not only their significance for modern technologies but also their rising demand and vulnerability to supply disruptions.

A mineral's criticality is determined by prevailing geopolitical and market conditions at a given time and is subject to change.⁴ Hence, the criticality of a mineral varies depending on the purpose, the time scale and context. As such, several regions and countries in the world classify their ‘critical’ minerals based on perceived state interests of geopolitical, economic and technological parameters.

For example, the United States of America (USA), under Presidential Executive Order 13817 of 20 December 2017, classify critical minerals based on three parameters: 1) minerals vital to economic and national security; 2) susceptible to supply chain disruptions; and 3) vital in product manufacturing.² Based on these parameters, the US Geological Survey (USGS) delineated 50 critical minerals in 2022,³⁸ 23 of which have been evaluated for their criticality in clean energy,³⁹ and 45 are also considered critical minerals of interest by the US Defense Logistics Agency (USDLA).



Bauxite specimen. Photo by USGS.



Wolframite specimen. Photo by USGS.

The European Union (EU) has identified 34 critical raw materials considering their economic importance and supply risk to EU countries, and 17 of these are delineated as strategic raw materials due to their significance for national security, technology and digital transition.⁴⁰ Strategic minerals differ from critical minerals in that their supply chains are not vulnerable. Australia's critical mineral list for 2024 which replaced the 2022 edition, contains 31 minerals.^{41,42} This list added nickel to Australia's critical minerals which was previously classified as a strategic material. The Organisation for Economic Co-operation and Development (OECD) considers 12 to 20 minerals critical for its member countries,⁴³ a narrower range than the International Energy Agency (IEA), which lists 26 critical minerals.⁴²

Each country or region delineates their list of minerals based on some specific indicators and priorities. Thus, the ‘criticality’ of a mineral is a subjective construct shaped by the strategic considerations of national interests. For example, the US, Europe, and Australia classified certain groups of minerals as ‘critical’ because they found them essential to national security and economic transition while being susceptible to supply risk.^{39,41} However, the same minerals may not be ‘critical’ for some countries in the Global South, particularly in Africa, as most of these countries are less industrialized and lack the technology to process these minerals for national benefit,⁴ sustainability transition, and national security. This suggests that although there is a race for critical minerals in Africa and other regions in the Global South, these resources primarily serve the geopolitical and economic interests of the Global North,

as well as wealthy nations like China, which despite being part of the 'Global South', plays a leading role in the global critical minerals supply chains.⁴⁴

Collectively, critics have argued that the conceptualization and broader strategic frameworks for critical minerals are closely tied to the geopolitical and economic ambitions of the Global North, with the potential to lead to what has been described as 'climate coloniality'²⁸ where global capitalism intersects along with the climate change narratives, which are mostly shaped by the concerns of the richer nations, may (re)produce and worsen various forms of inequalities and social injustices in the Global South. In other words, the global rush for critical minerals secures immediate socio-political and environmental benefits enjoyed in the Global North which are built upon the burdens placed on communities in the Global South,^{10,13} which can exacerbate the global inequality and injustice problems. The geopolitical conflicts, the lack of access to clean water and sanitation, the battering

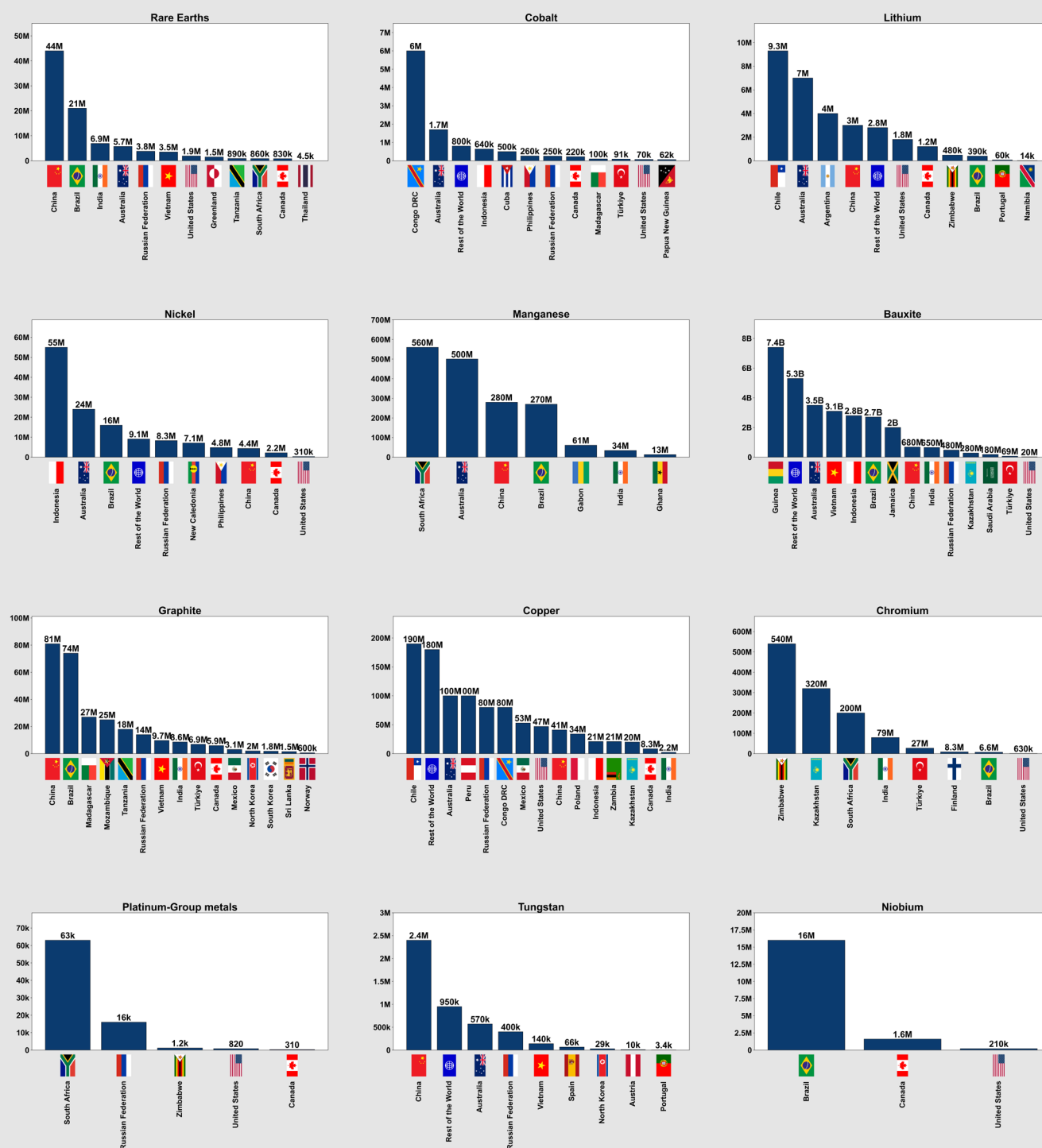
of bodies, the forcible displacement of communities, the disruption of social capitals and capabilities, are all embodied experiences of communities and individuals experiencing critical minerals extraction in the Global South.^{8,10,12,13,45} These communities often have limited capability to regulate or dictate the extraction processes for their long-term socio-economic, environmental, security benefits, which further limit their ability to frame their experiences and communicate their outstanding concerns and frustrations.^{13,28}

While reserves of various critical minerals exist all over the world, their distribution is geographically uneven. Australia holds substantial amounts of Cobalt reserves and is a major producer of Bauxite and Lithium. The US had around 25% of the world's known Molybdenum – a mineral mostly used in solar and wind power generation – reserves as of 2021.⁴⁶ But a significant majority of the world's known, declared, and exploited critical mineral reserves are located in countries of the Global South. Africa holds 30% of the world's critical



Workers in a cobalt mine, DRC. Photo by IIED/Flickr/Wikimedia Commons.

Global Reserves of Critical Minerals Required for Energy Transition (tonnes)



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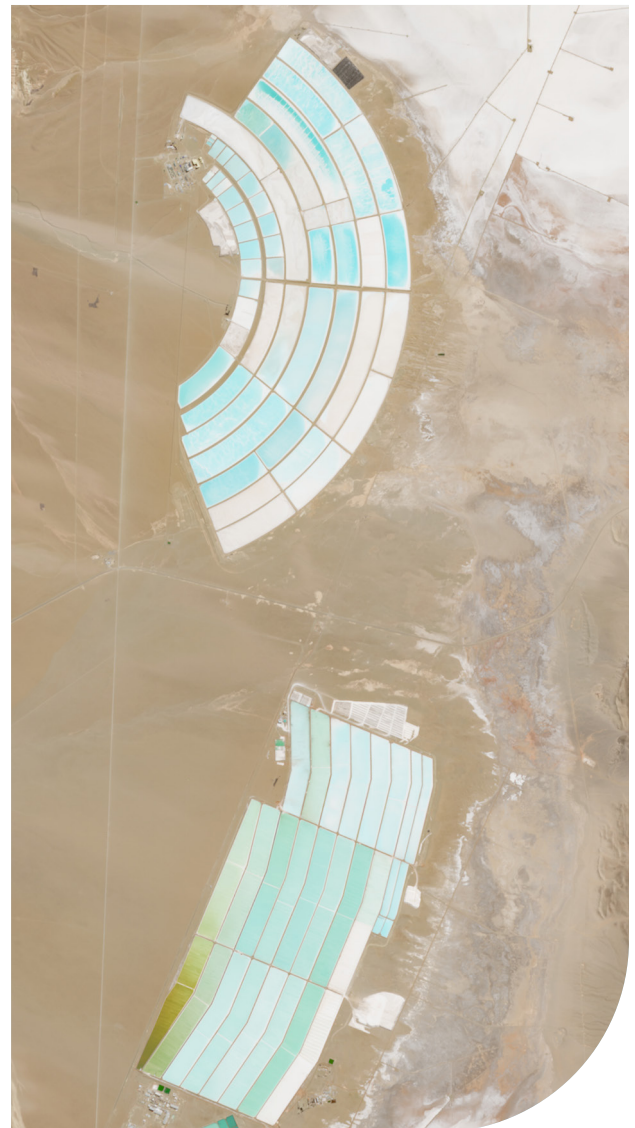
Figure 4. Global reserves of selected critical minerals required for the energy transition, based on data from the *U.S. Geological Survey's Mineral Commodity Summaries 2025*. Each panel ranks the countries with the largest identified reserves, with values standardized to tonnes.⁴⁷

For example, the DRC, Madagascar, and Morocco have over 50% of the global cobalt deposits,⁴⁸ a vital mineral required for the development of batteries. The global share of cobalt produced in the DRC remains above 60% from 2020 to 2024. South Africa possesses about 90% of the global platinum reserves and is responsible for about 70% of the global production.^{49,50} Platinum group metals are critical for developing clean hydrogen technologies and reducing carbon emissions. The global chromium resources (95%) are geographically concentrated in Kazakhstan and southern Africa.⁵¹ South Africa holds about 36% of the global chromium reserves.⁴⁵ Chromium is a critical mineral in the development of low-carbon technologies such as geothermal, solar, and wind. South America's "Lithium Triangle," which includes Argentina, Bolivia, and Chile, holds over 50% of the world's lithium reserves,⁵² a critical component of lithium-ion batteries. Indonesia has 42% of global nickel reserves. In 2023, the Indonesian share of the global nickel production was 51%, compared to 34% in 2020, followed by the Philippines, which contributed 11% of the global output.⁵³

One must note, however, the production locations of these minerals do not always reflect their ownership. Therefore, while some countries may lead in the raw material production of critical minerals, their domestic firms do not always reap the primary economic benefits or control the downstream supply chain. For example, although the DRC currently dominates global cobalt production, over 80% of its output comes from foreign-controlled industrial mines, with the remainder supplied by artisanal and small-scale miners.⁵⁴⁻⁵⁷ This is also the case in Indonesia where Indonesian companies hold less than 10% control of Nickel production.⁵⁷

In many parts of the world, critical mineral extractions are concentrated in regions of socio-economic and ecological vulnerability. For example, while the extraction of cobalt in the DRC presents an opportunity for economic growth, it is also a context where significant social vulnerabilities exist, including conflicts, and human rights abuses (such as child labor and gender-based violence).^{8-10,32,33,58} About 73.5% of population in the DRC live on less than \$2.15 a day,⁵⁹ which reflects their financial

inability to reap the benefits of low-carbon technologies. Recent evidence suggests that around 54% of global critical mineral projects for energy transitions are located on or nearby indigenous peoples' and peasant land.^{60,61} The industrial extraction of critical minerals exacerbates local inequalities and weakens community's social capital due to its detrimental social impacts.⁶² Mining operations are known to threaten indigenous land rights, land-based livelihoods, and cultural identity. Evidence also highlights the risk of social disruptions, disempowerment, forced displacements and destruction of protected areas.⁶³ These concerns transcend beyond the Global South to countries in the Global North such as Canada and Australia where there is strong local resistance among the Indigenous communities to critical minerals extractive operations.^{60,64}



Salar de Olaroz, a major lithium site in Argentina. Processed by UNU-INWEH using Sentinel-2 imagery.

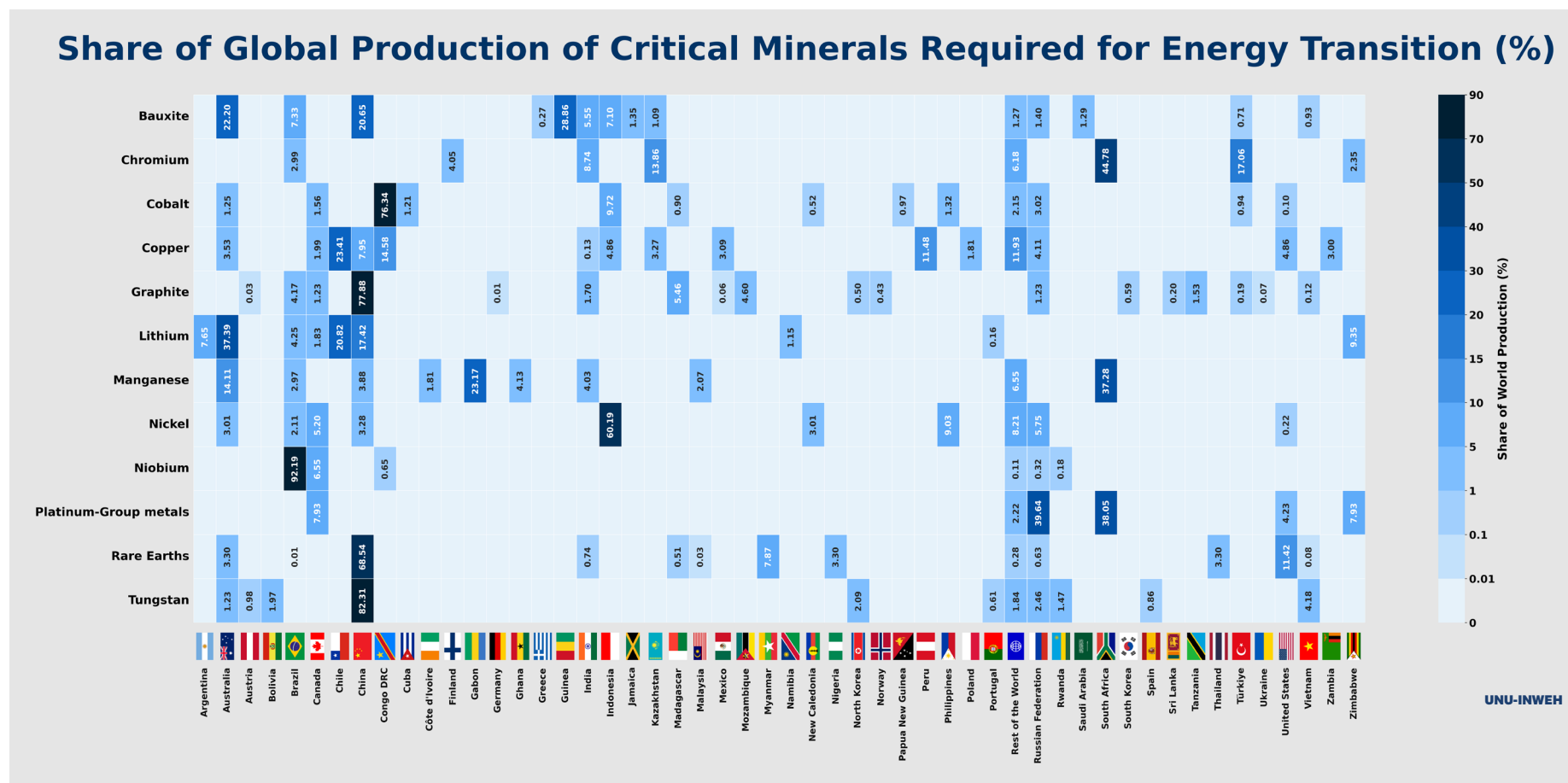


Figure 5. The share of global dry (non-refined) production for selected critical minerals required for the energy transition, using data from the U.S. Geological Survey's Mineral Commodity Summaries 2025. This compares country-level contributions across minerals, with values expressed as percentages of total world production.⁴⁷

Evidence suggests that critical minerals extraction sites are experiencing increasing ecological vulnerability. In the Lithium Triangle in Bolivia, Chile and Argentina, most areas are arid, with less rainfall and dry climates, sparse surface vegetation, vast soil erosion and air pollution.⁶⁵ Lithium extractive operations are exacerbating the region's ecological vulnerability, threatening not only ecosystem stability but also water resources.^{27,65} Physical water scarcity is one of the increasing challenges in most mining communities in this region. This occurs when the consumption of fresh water exceeds its availability. The consequences of water scarcity are borne by the most vulnerable and impoverished populations living near mining areas. In terms of drinking water, about 16% of populations in Bolivia still lacked improved water access, and the access gap between the richest and the poorest populations is 22% (77% vs 99%).⁶⁶ The extraction of lithium, which requires substantial amounts of water, raises concerns about potential contamination and disruptions to their water sources. In sub-Saharan Africa, DRC is one of the countries with lowest rate of access to drinking water despite possessing over half of Africa's freshwater reserves, a good example of a nation suffering from economic water scarcity where inadequate investments in infrastructure and technologies limit the population's capacity to benefit from the available water resources.

According to United Nations Children's Fund (UNICEF) and the World Health Organisation (WHO),⁶⁷ about 64% of the population in DRC lacked basic access to water in 2024. This means that about 64% of the population obtain their drinking water either from surface water sources and unprotected dug wells, or from improved sources where the collection time – including queuing – exceeds 30 minutes for a round trip. The increasing contamination of freshwater bodies and ground water by mining activities further exacerbate the water situation particularly in rural communities who are mostly less likely to have basic drinking water access.

Yet, achieving the global targets as outlined in the Paris Agreement, would require a ninefold increase in lithium demand and a doubling of the current demands for cobalt and nickel by 2040. The trend in demand for minerals such as lithium and graphite implies that the production of these minerals will continue to increase. This increase in production will also necessitate more water usage to realize these projections. Undoubtedly, critical minerals extraction affects water security in local communities, with significant socio-economic, health, justice, and security implications. This report is a step forward in highlighting such under investigated impacts and a call for addressing them through international cooperation.



Children and adults cleaning and washing minerals in Kakanda, DRC (October, 2023). Photo by Didier Makal/Mongabay.

3. Critical Minerals: Water Insecurity and Injustice in Global Sustainability Transitions



Washing copper ore, Katanga, DRC. Photo by Fairphone/Flickr.

Despite the potential benefits of critical minerals, the global surge in demand has raised serious concerns about negative externalities and environmental challenges, particularly in the Global South.¹⁻⁹ The global energy, digital and sustainability transitions is unfolding alongside a troubling paradox whereby, in many regions where these resources are mined, their extraction has led to severe environmental concerns, including water insecurity, i.e. the inability to access and benefit from affordable, adequate, reliable, and safe water, that further deepens the socioeconomic vulnerability of disadvantaged communities.⁹⁻¹⁷

3.1 Water Insecurity

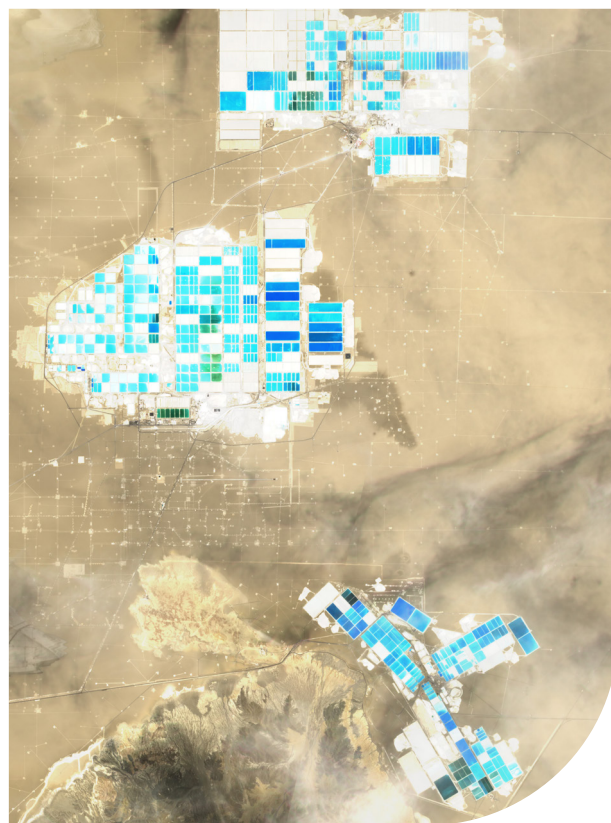
3.1.1 Water Scarcity and Depletion

Extracting critical mineral requires a substantial amount of water, especially during the mining and processing stages.^{2,4,68} This poses a serious threat to freshwater supplies, which are already scarce in many mining areas, making local communities more vulnerable. Lithium extraction, for instance, is extremely water-intensive,⁶⁹⁻⁷¹ with estimates indicating that about 1.9 million liters of water is needed to produce just one ton of lithium.^{68,72} An average lithium mine producing 11,000 tons of lithium annually^{73,74} uses roughly 20 billion liters of water. This amount is enough to cover the annual domestic water needs of 2.8 million people in sub-Saharan Africa.

In 2024, US production excluded, the global lithium production was about 240,000 metric tons.⁷³ Processing this volume of lithium would require about 456 billion litres of water, sufficient to meet the annual domestic water need of about 62 million people in sub-Saharan Africa. In lithium-rich regions such as Chile's Salar de Atacama (where freshwater resources are already scarce) lithium and copper mining is estimated to account for up to 65% of regional water usage, surpassing the combined demand from key sectors like agriculture and industry.⁷² Globally, approximately 16% of critical mineral mining sites are located in areas already classified as water-stressed.^{72,75} Expanding extraction in these regions is therefore likely to exacerbate water scarcity, intensify competition for limited freshwater supplies, and threaten the availability of

water for other equally critical sectors including agriculture, domestic consumption, and industry.^{76,77} Severe water scarcity also disrupts both the ecological and hydrological cycles in the long term and impact water resource availability. These impacts are already evident in mining regions of Bolivia and Chile.^{18,68,78}

The excessive usage of water by the mining industry contributes to the depletion of groundwater^{79,80} and that exacerbates water insecurity risks in communities that are already facing water scarcity. The Lithium Triangle illustrates this challenge vividly. The triangle, encompassed by the borders of Argentina, Bolivia, and Chile is one of the world's richest places in terms of lithium reserves while being one of the world's poorest places in terms of water availability.^{68,72,77} In such arid environments, lithium mining is projected to further escalate the problem of water scarcity to unprecedented levels,^{80,81} increasing both ecological degradation and the vulnerability of local populations.^{65,72,76,82} Empirical evidence indicates a consistent decline in water resources within the Salar de Atacama region, Chile.



Lithium mining area in Chile's Atacama Desert (false color). Processed by UNU-INWEH using Sentinel-2 imagery.

For instance, between 2010 and 2017, the total water storage (surface water, soil moisture and groundwater) declined by 1.16mm per year⁷⁰ whilst soil moisture indexes experienced an annual reduction of 0.005 on average from 1997 to 2017.⁸³ Groundwater monitoring data further confirmed a substantial drop in the water table between the pre-extraction period and the years 1986 to 2015.^{71,84} In areas with brine wells, water table dropped by up to 9 meters from 1990 to 2015.⁷¹

Mining in the salt flats of the Lithium Triangle involves pumping large volumes of lithium-rich brine from underground aquifers and leaving it to evaporate in large ponds.^{68,79,82} Although brine water is not suitable for

human consumption or agricultural use, its large-scale extraction can disrupt local hydrological cycle and freshwater aquifers.⁸⁵⁻⁸⁷ There is growing evidence that extensive brine extraction alters subsurface pressure balances, potentially disturbing adjacent freshwater aquifers as this fresh water can seeps in and fill the void and thus accelerates aquifer depletion.⁸⁶⁻⁸⁸ Moreover, the withdrawal of saline water leads to saltwater intrusion into nearby freshwater aquifers, further compromising water quality and rendering it unsafe for human consumption. The depletion and degradation of freshwater resources because of mining activities thus intensify water insecurity experience for local communities.^{68,72,76}



Abandoned barges on the Congo River show the collapse of a once-vital transport system between Kisangani and Kinshasa. Photo by Julien Harneis, Flickr.

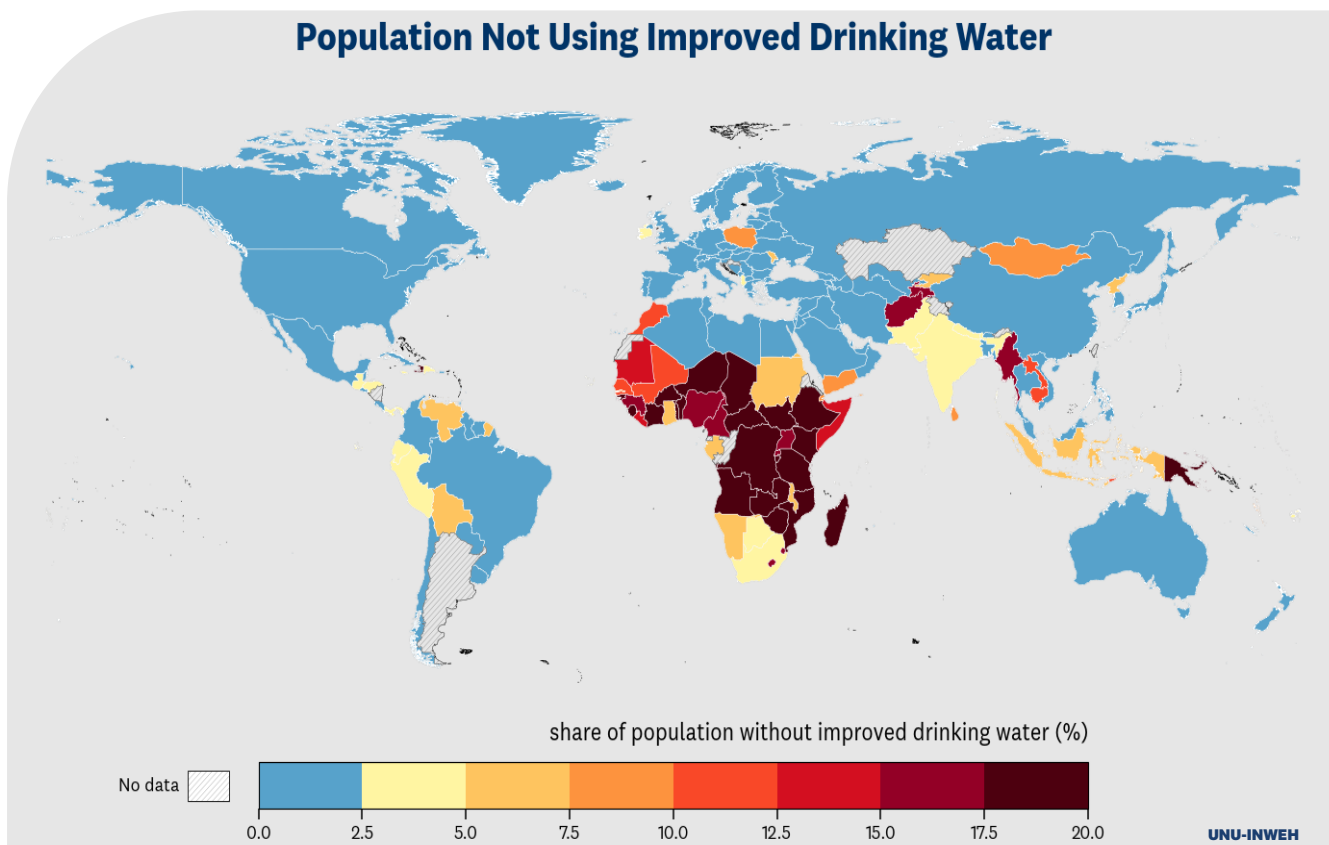


Figure 6. Improved drinking water sources are water supplies classified by infrastructure type, including piped connections, boreholes or tubewells, protected wells and springs, rainwater harvesting, and packaged or delivered water. Data are from the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (2024), processed by Our World in Data.^{37,89}



Residents of Budwale sub-county in Mbale District, Uganda, wait in line for water after a prolonged dry spell, with women and children spending up to two hours to fill a single jerrycan. Photo by Lubega Ibrahim / Wikimedia Creative Commons.



Salt harvest in the Uyuni salt desert, Bolivia. Photo by Alexander Schimmeck/Unsplash.

In Bolivia's Salar de Uyuni region (the world's largest salt flat and home to massive untapped lithium reserves), the Bolivian government promotes lithium development as a pathway to national economic growth and energy sovereignty, but concerns about water scarcity are mounting. Communities near San Pedro de Atacama and other parts of the Potosí region have reported visible declines in groundwater levels, raising alarms about the long-term availability of water for domestic use, agriculture, and wildlife. This situation highlights the difficult trade-offs between economic growth and water security. As a local resident captured the paradox succinctly: "There is development, but there's also the water issue—and they contradict each other. Everyone needs money, but everyone also needs the basics, like healthcare and education. Our grandchildren—they're the ones who will suffer."⁷⁶ Despite state-led promises of reinvestment and sustainable practices, limited transparency and weak enforcement of environmental safeguards have deepened public skepticism. The growing perception is that lithium development may bring short-term financial gains while compromising the environmental security of future generations.



A water and sanitation monitoring mission in the Democratic Republic of the Congo underscores the need for safe, accessible clean water, as women and girls face violence risks when collecting it far from their villages; photo by EC/ECHO/Damien Blanc, EU Civil Protection and Humanitarian Aid//Flickr

The water problems of the regions with critical minerals reflect paradoxical situations whereby the critical minerals mining industry, which is supposed to drive the global transition to low-carbon and sustainable technologies is, in the process, threatening and deepening water scarcity and environmental problems in mining communities. Given the critical role of freshwater in supporting human survival, jobs, food security, biodiversity, and the achievement of broader sustainable development goals, these emerging dynamic poses serious long-term risks that demand urgent policy attention and mitigation.

Water pollution is a major consequence of mining, contributing to water insecurity. Even when water is physically abundant, contamination can render it unsafe, unusable, and inaccessible for communities. The pollution of water bodies through chemical contamination has been frequently reported as a major concern associated with critical minerals mining.^{87,88} There is considerable evidence that the extraction of critical minerals generates large volumes of wastewater and hazardous chemicals, including heavy metals, sulphur compounds, and industrial acids used during mining operations.^{86–88}

Producing one metric ton of rare earth elements generates approximately 13

kilograms of dust, 9,600 to 12,000 cubic meters of waste gas, 75 cubic meters of wastewater, one metric ton of radioactive residue and up to 2,000 tons of toxic waste overall.^{90,91} Taking these numbers into account, the toxic waste of the global production of rare earth elements in 2024 is estimated to be 707 million metric tons, with about 70% (490 million metric tons) of that generated in China. This quantity of global toxic waste is equivalent to nearly 59 million fully loaded garbage trucks, or the weight of 118 million elephants, matching the annual municipal (household) waste produced by approximately 1.4 billion people—more than the combined populations of Europe and Africa's largest nations. These toxic wastes, when discharged into water bodies without proper treatment, cause severe contamination of rivers, streams, and other freshwater sources, making them unsafe for human and animal consumption. In regions where critical mineral mining activities are prevalent, incidents of water pollution are common and widespread due to chemical spillages and industrial pollution.^{26,88,92,93} Such contamination is not limited to water bodies but also impacts soil and underground aquifer contamination.^{86,87} Soil pollution can affect crops, animals and human health either directly or through processes of biomagnification and bioaccumulation, leading to serious health outcomes.^{26,92,93}



Community meeting on lithium mining in Uyuni, Bolivia (December 2022). Photo by Maxwell Radwin/Mongabay.

Population Not Using Improved Sanitation Facilities

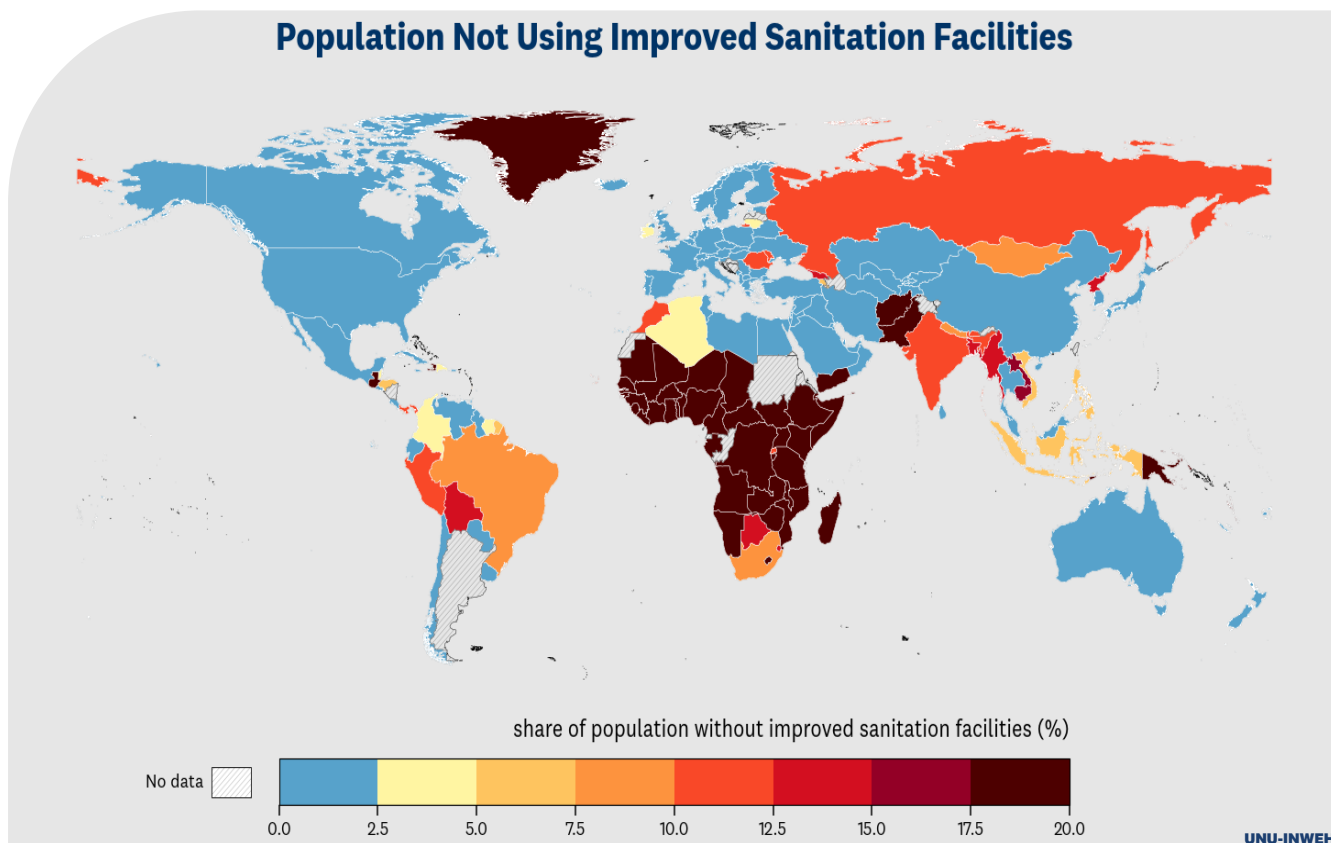


Figure 7. Improved sanitation facilities are those intended to ensure hygienic separation between human excreta and direct human contact. These include flush or pour-flush toilets connected to sewer systems, septic tanks, or pit latrines; pit latrines fitted with slabs (including ventilated pit latrines); and composting toilets. Data are from the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (2024), processed by Our World in Data.^{37,89}



Schoolgirls stand outside a newly built girls' toilet block at their school in Togo, where poor sanitation remains a major health risk for children and communities.



Lualaba River near Haut-Lomami Province, located in the wider mining region of southern DRC. Photo by OtikolenoiL/Wikimedia Commons.

The environmental and public health consequences of critical mineral extraction are increasingly evident in communities located near major mining sites. In Fungurume, located in the Lualaba Province of the Democratic Republic of the Congo, copper and cobalt mining operations are carried out by Tenke Fungurume Mining (TFM), one of the nation's largest copper and cobalt producers. This area, rich in critical minerals vital for electric vehicle batteries and renewable energy technologies, has witnessed rapid industrial expansion. However, this development has come with significant environmental costs. Multiple investigations have reported serious contamination of local rivers and water bodies, primarily from discharge of sulfuric acid, heavy metals, and other toxic chemicals used in the extraction and leaching processes. The once-pristine rivers that local communities depended on for drinking water, irrigation, and fishing have been dangerously polluted. A recent study found five regional water bodies to be severely affected by acidified industrial pollution. For example, the Katapula and Kalenge rivers have a pH of less than 3.8, classifying them as "hyper-acidic." The Dipeta and Dilala rivers are categorized as "very acidic," with a pH below 4.5. In contrast, Kando Lake has a pH of 6.5, which is considered "slightly acidic" and is close to the neutral pH value of 7.⁹⁴ Even though the Democratic Republic of the (DRC) holds more than 50% of Africa's water reserves, it has one of the lowest rates of access to drinking water and adequate sanitation in sub-Saharan Africa.⁹⁵ Community members have stopped drinking from rivers that once served as their primary water source. Additionally, the soil in the region has been contaminated with heavy metals⁹⁶, reducing agriculture productivity, compounding food insecurity in already vulnerable areas.⁹⁴

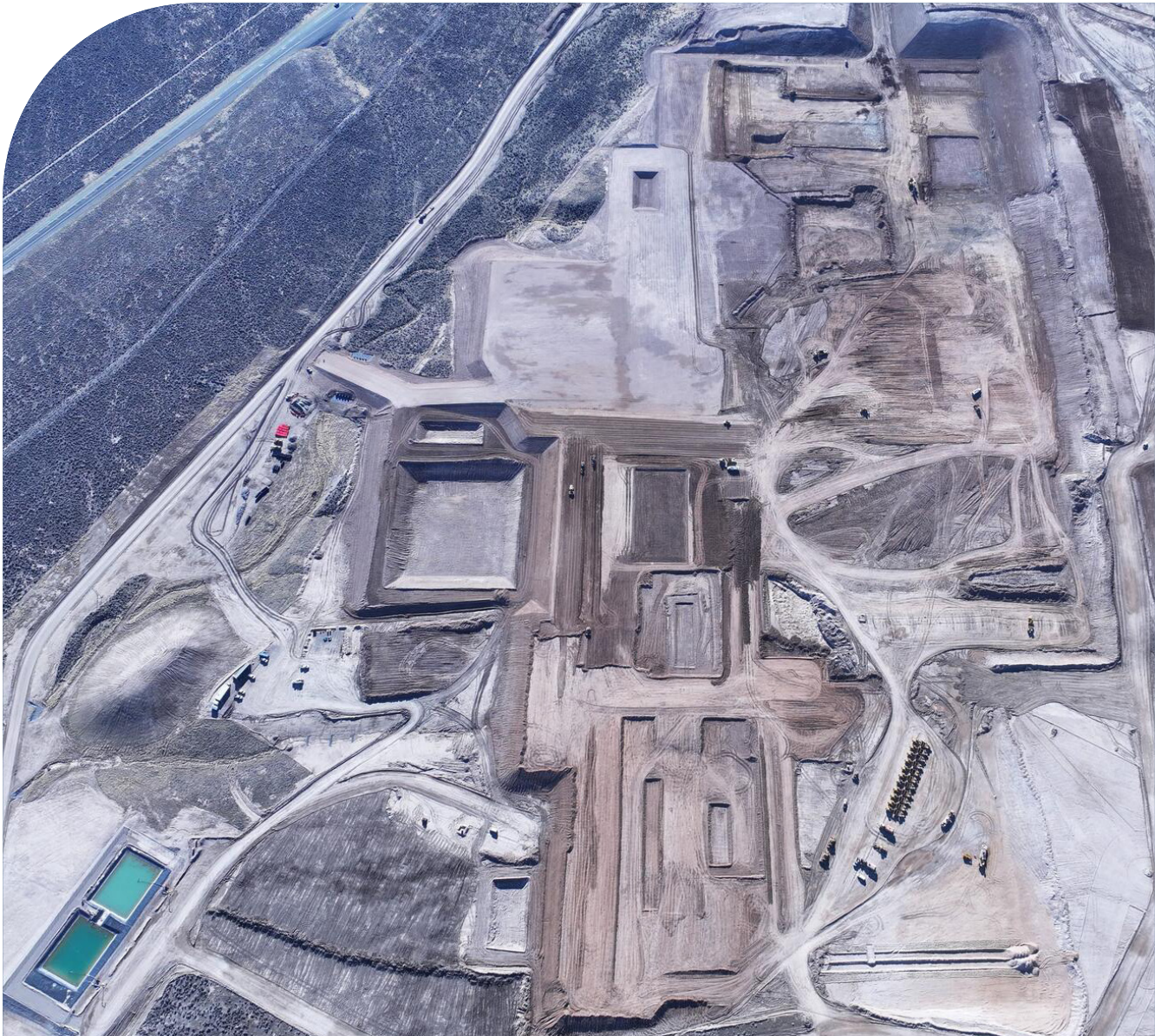
Water pollution is among the widespread and recurring externalities of critical mineral mining across the globe, including the Global North. Mining activities continue to make water resources unusable and unavailable for productive livelihoods activities. As contamination of water bodies spreads, the availability of safe and usable water resources diminishes. In many instances, treating water polluted by heavy metals and toxic chemicals is either prohibitively expensive or technologically unfeasible. Consequently, mining-related chemical pollution can permanently degrade once-usable water sources, exacerbate water insecurity and pose significant public health risks for individuals and communities.

3.1.2. Water Insecurity and Local Agricultural Livelihoods

Water insecurity resulting from critical minerals extraction and procession is a growing threat to community agricultural livelihoods security. The expansion of mining activities in the Global South has resulted in communities being dispossessed and displaced from agriculture lands and freshwater resources that once supported their agricultural activities. For instance, in the case of platinum mining in the Limpopo Province of South Africa, local communities reported incidences of agricultural livelihood insecurity due to the loss of land and freshwater ecosystem.^{25,97} This loss contributed to a decline in livestock production.²⁵



Artisanal wolframite and cassiterite mining in Kailo, DRC. Photo by Julien Harneis/Flickr.



Thacker Pass lithium mine, February 2025. Photo by Lithium Americas/USGS.

In the desert of northern Nevada, near the small town of Orovada, lies the Thacker Pass mine — the largest known lithium deposit in the United States. In 2021, the Bureau of Land Management approved plans to mine the area. Today, Thacker Pass is considered one of the most important lithium mining projects in the world, with the potential to supply up to 25% of global lithium demand.⁹⁰ At a time when the world is trying to reduce fossil fuel use, the project was welcomed by the U.S. government and investors as a key part of the clean energy transition. But on the ground, the situation is more complicated. Unlike most lithium mines, Thacker Pass will mine lithium from clay.⁹⁴ This process requires up to 3.5 billion liters of water each year.¹⁰⁰ This demand is a major concern in Humboldt County of Nevada where water resources are already limited. More problematic is that such a massive requirement would be met by diverting water and transferring water rights from farms in the Quinn River Valley.¹⁰¹ This will lead to water scarcity and displacement of local communities and ranchers, who depend on this water for irrigation and cattle rearing.^{99,102} For many local residents, the mine brings fears of displacement and loss of livelihood. Thacker Pass case highlights the difficult choices involved in the global digital, energy, and sustainability transition and that even in wealthy, developed regions like the USA, mining for critical minerals can come with serious water, environmental, and social costs.

The depletion of freshwater resources caused by mining has led to water scarcity and heightened competition for freshwater, making agriculture more vulnerable in some mining regions. Evidence on lithium extraction in the Lithium Triangle show that brine evaporation depletes water sources and introduces contaminants into local water bodies. In this region, lithium mining has reduced water supplies for both crops and farm animals.¹⁰³⁻¹⁰⁵ Many people now need to walk long distances to find clean water and green fodder for their livestock, increasing their daily workload and weakening already fragile livelihood systems.⁶⁸ In Bolivia's Uyuni region, lithium mining has also led to water shortages, making it difficult to grow quinoa¹⁰³⁻¹⁰⁵ – a staple crop essential to the local economy and food supply – in a wider context of declining public investment in water services.^{106,24,25}

Mining operations equally contaminate waterbodies and the surrounding environment with heavy metals, which severely impacts aquatic life, particular fish. In such situations, communities, whose livelihoods depend directly on the aquatic ecosystems, are among the most affected. For example, in the Jinjiang River basin in China, lithium extraction was found to have contributed over 95% of dissolved lithium downstream, increasing lithium presence in water, aquatic plants, and fish, thereby posing livelihood risks and insecurities among local farmers.¹⁰⁷ Further examples from the DRC indicate that toxic chemicals and heavy metals used in mining have polluted rivers, leading to fish deaths⁹⁴, and a decline in fish diversity and yields.¹⁰⁸ Similar evidence was recently reported in Zambia following an acid spill at a copper mining site in February 2025. In this incident, toxic effluent from a collapsed tailings dam contaminated the Kafue River, killing fish and destroying food crops.^{109 32,33} In Peru, the contamination of the Cunas watershed from Zinc mining activities is adversely impacting food crops cultivation, livestock rearing and dairy production within local communities.^{110,111}

The deepening extractive activities across mining communities in the Global South have significantly affected local livelihood systems. While nations may be 'progressing' in critical minerals extraction, vulnerable communities and individuals are often left behind, with

poverty produced and reproduced in new ways that limit the ability of the poor to pursue better opportunities and livelihoods.

3.2 Emerging Health Disparities

The health disparities of critical minerals are the unfair and avoidable or remediable systematic health outcomes associated with environmental exposure to mineral contaminants. These health outcomes are often influenced by a combination of disadvantages including the water, sanitation, and hygiene (WASH) conditions in which people live. Research has directly linked contamination of surface and groundwater from critical minerals extraction to significant health risks for local communities. An empirical study, which examined the impacts of cobalt and copper mining activities on the health of local communities in the DRC, revealed health inequities, across the life course.⁹⁴

Approximately 72% of the respondents reported skin diseases and dermatological problems. Specifically for women and girls, about 56% of them reported an increased incidence of gynecological issues among women, while 14% reported similar issues for teenage girls.⁹⁴ The majority of the local residents believed their health status has been impacted negatively and that diseases and hospital visits are more frequent than prior mining. These concerns have also been echoed by the medical personnel in the region.¹¹²



Two Rivers platinum mine, South Africa. Photo by Ryanj93/Wikimedia Commons.



Mount Polley mine near Williams Lake, British Columbia. Photo by Mount Polley Mining Corporation.

On August 4, 2014, the tailings dam at the Mount Polley copper and gold mine collapsed in British Columbia, Canada. This led to the release of about 25 million cubic meters of toxic waste—made up of water and crushed rock—from the mine’s tailings pond into nearby rivers and lakes.^{113,114} The slurry flowed through Polley Lake, down Hazeltine Creek, and into Quesnel Lake, one of the deepest fjord lakes in the world and an important tributary of the Fraser River. These freshwater bodies supported aquatic life and served as drinking water sources for nearby communities. Environmental records from 2013 showed that the tailings pond contained large amounts of hazardous materials, including, nickel, arsenic, lead, copper and copper compounds.¹¹³ After the dam broke, the slurry ripped up trees, eroded the banks of Hazeltine Creek, and filled lakes with contaminated waste. Water testing showed high levels of metals like zinc, which can harm aquatic life.¹¹³ The disaster also affected the livelihoods of local communities, particularly Indigenous communities.^{114,115} The Mount Polley mine disaster is now considered one of Canada’s worst mining-related environmental failures, raising concerns about mining safety, water pollution, and the long-term effects on people and ecosystems.

The harms and health burdens of water contamination are not shared equally. Women and children are disproportionately impacted. Their close interaction with the environment and polluted water sources makes them disproportionately vulnerable, particularly in terms of gynaecological and reproductive health. There are documented cases of multiple miscarriages, menstrual health disorders, genital infections, and birth complications among women and girls of reproductive age in mining communities. In most of these contexts, women and girls are disproportionately exposed to contaminated water bodies because of their gendered roles in WASH provision for their households.¹¹⁶ They are primarily responsible for collecting water from rivers, lakes, and wells for household use including drinking, cooking, washing, and personal hygiene.^{117,118} Beyond the exposure to mineral contaminants, the lack of access to safe water for hygiene and sanitation further compounds their vulnerability.

Higher concentrations of heavy metals in water have also been linked to an increased risk of congenital malformations such as neural tube defects. Neural tube defects are congenital disabilities of the brain and spinal cord that occur when the neural tube, which develops into the brain and spinal cord, does not close completely during early pregnancy. A study in Lubumbashi, DRC, found that the incidence of neural tube defects, lower limb defects, cleft lip, and abdominal wall defects was higher in maternal wards located near mining areas compared to those situated farther away.¹¹⁹ The study further reported that among the births with visible malformations, neural tube defects were the most prevalent, occurring at a rate of 10.9 per 10,000 births, followed by lower limb defects at 8.8 per 10,000, cleft lip/palate at 7.2 per 10,000, and abdominal wall defects at 6.4 per 10,000. Another study reported an association between congenital malformation and paternal mining jobs in Lubumbashi, DRC¹⁵ without establishing a clear pathway for parental exposure.

Water and environmental contamination have denied some children the right to a healthy life. Exposure to mineral contaminants have triggered several health crises among children. Empirical evidence and reports from Cerro de Pasco, Peru, show that exposure

to mineral contaminants is chronic among children which implies negative consequences on their health.^{120–122} For instance, exposure to mineral contaminants increased risks of health conditions such as nosebleed, chronic colic, dermatologic alterations, constipation, and mood alterations among children living near mining sites.¹²⁰ The primary pathway of exposure for many children is through contaminated water and air, which is often used for drinking and cooking despite being tainted with mine runoff and tailings waste. Long term exposure to heavy metal contaminants is associated with the development of kidney failure, cancer and neuronal damage. In Chile's Norte Grande region, such as in the cities Calama in the copper mining region of Antofagasta, medical doctors have raised concerns about the surge in cases of autism and other developmental disorders in children.¹²³ Similarly, in the DRC, about 56% of respondents in a study reported negative health impacts on children, stating that they appear to be affected by water pollution more severely than adults.⁹⁴



Female sapphire miners in Ambatondrazaka District, Madagascar (sapphire is a corundum mineral composed of aluminum oxide with trace elements). Photo by RoseyPerkins/Wikimedia Commons.

Mortality Rate Attributed to Unsafe WASH Services

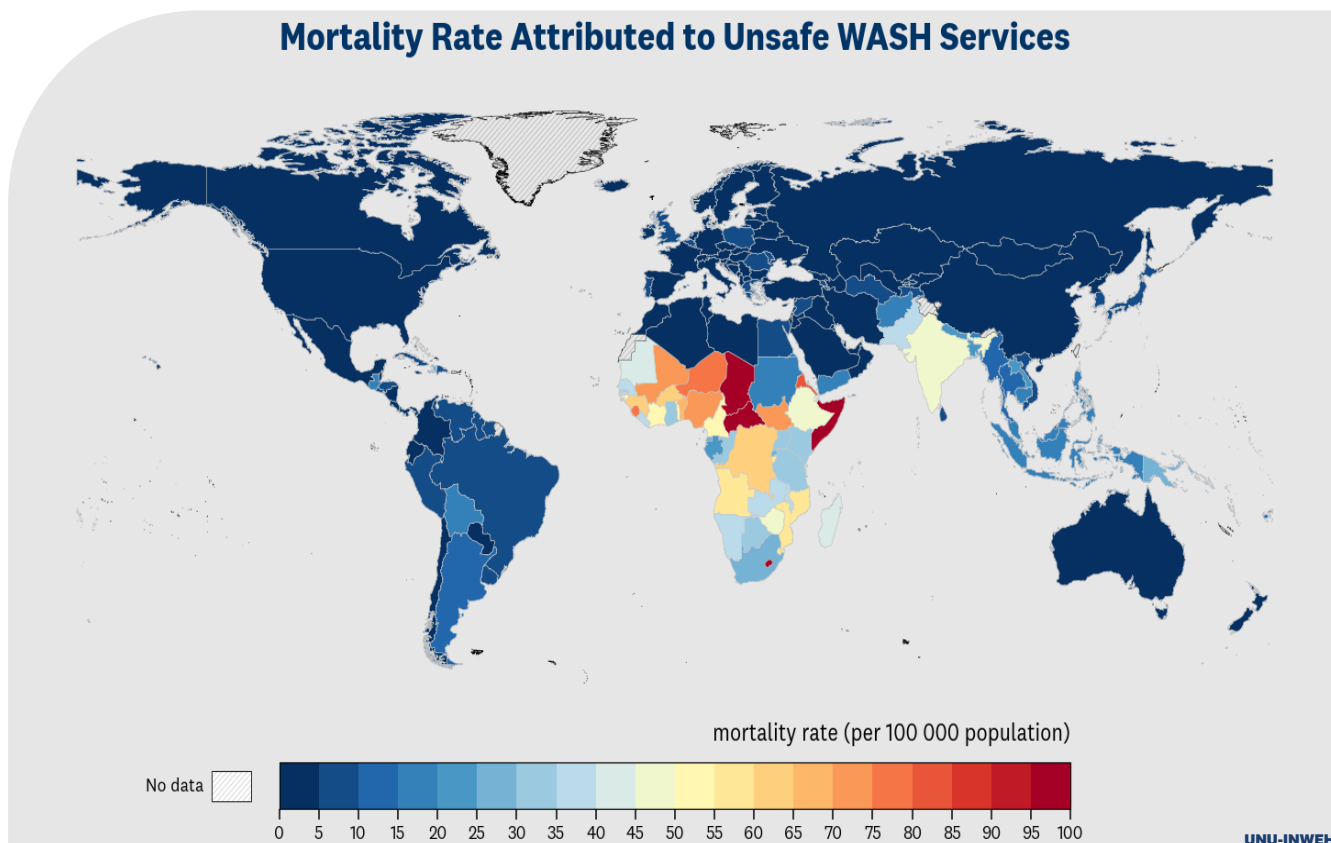


Figure 8. Mortality from unsafe water, sanitation, and hygiene (WASH) across countries. This is defined under SDG indicator 3.9.2 to reflect the number of deaths per 100,000 population linked to inadequate WASH services, based on WHO's comparative risk assessment and cause-of-death estimates.^{37/124}



Women collecting clean water in Baraka, DRC, where years of cholera linked to Lake Tanganyika have declined after new piped water systems were built. Photo taken 17 June 2007 by Julien Harneis/Flickr.



Coltan (Tantalum) mining site in the DRC. Photo by Responsible Sourcing Network / Flickr, May 9, 2012.

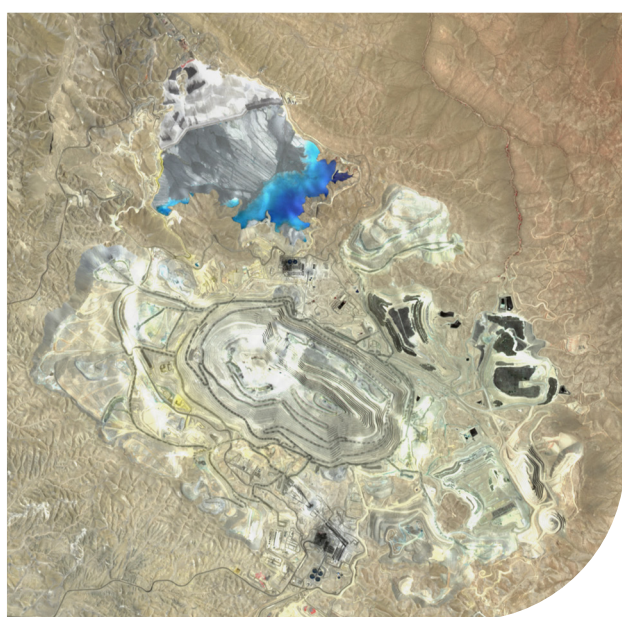
Local communities in the DRC have been dealing with serious health challenges linked to cobalt and copper mining activities. In Noa, a village situated near a mining site, one local describes the situation: “We live in an environment that brings us more problems than solutions. We are becoming sick; our soil and water are polluted [....]”⁹⁴

In Kahindu, there are reported cases of skin diseases: “Some women go to the lake to do laundry. Children swim there, and fishermen fish there. These people scratch a lot and complain about skin problems.”⁹⁴ Far away in Rianda, similar health concerns have been reported: “Our environment is so polluted; I’m really scared for my children”.⁹⁴

There is an increasing number of cases of infertility, urinary tract and vaginal infections, miscarriages, stillbirths, and infant mortality caused exposure to contaminated water. A Noa resident indicates the severe impacts on women and girls due to the consumption of contaminated water: “In our village, there are regular vaginal infections for women [...], and miscarriages.”⁹⁴ The experiences of Angèle, a 40-year woman who lived near Kolwezi, an industrial mining town in DRC, says “I have had four successive miscarriages in the last few years. When I reach three months of pregnancy, I start feeling pain in my lower abdomen. And then the pains get worse, and I lose the baby. Every time I conceive, the same thing happens. It’s hard.”¹¹²

In a worrying disclosure, one of the affected women living in Kolwezi reported that: “In 2017, I gave birth to a child with a malformation; he only had three fingers. At the hospital, when they asked where I lived, the doctor said the malformation was related to pollution from the mines [...]”.⁹⁴ The narrative of a medical staff in Kolwezi also highlights congenital malformation of babies and birth defects: “I see a lot of cases of threatened miscarriages and premature births. Sometimes, a pregnant woman arrives, complaining of abdominal pain. When I do an examination, I can see that the fetus is already dead and starting to decompose” [...].¹¹²

Living in polluted environments increases risks of psychosocial distress. The psychosocial health burden of living in polluted environments is severe. Living with water insecurity and negotiating access to safe water is associated with heightened levels of anxiety, depression, shame and in extreme situations, elevated levels of suicide.^{125,126} The stress of living with inadequate access to safe and reliable water transcends beyond the material value of water to the embedded health outcomes of lacking safe water. Numerous studies have shown that exposure to pollution significantly increases mental health problems and psychosocial stress.¹²⁷ The voices of affected individuals reflect their everyday emotional struggles and hopelessness. In Mibanze, DRC, for example, residents expressed despair over the widespread pollution of their water resources by mining companies and the potential devastating impacts on future generations.⁹⁴ Similar sentiment exists in Calama, Chile, where communities frequently voice frustration at being “sacrificed”, in relation to the painful ways their health and lives are being sacrificed for mineral wealth.¹²³ Continuous exposure to mining pollution has left the residents of Calama living in constant fear and anxiety about their increased risk of contracting diseases.¹²³ For parents with sick children, the psychosocial toll can feel like the shattering of dreams as the hopes and expectations they have for their children are all shattered.¹²³



Cerro Verde copper mine, Peru (false color). Processed by UNU-INWEH using Sentinel-2 imagery.

3.3 Economic, Environmental, Social and Health Injustices

The impacts of critical mineral extraction are not shared equally around the world. Injustices in this area reflect the unfair and disproportional shares of the benefits and harms of extracting, processing, and trading critical minerals. Often, the poor, vulnerable and marginalised communities and nations suffer the most from environmental damages, socio-economic harms, and health risks, while more privileged and richer groups and nations enjoy the benefits.

Economic injustices

Economic injustice occurs when the financial benefits, wealth and resources resulting from the extraction of critical minerals disproportionately flow to certain socio-economically and politically privileged groups, mostly in wealthy communities and advanced economies while the already poor and vulnerable populations bear the economic costs in the form of environmental and livelihood quality degradation, pollution, land dispossession, poor working conditions, health risks,¹²⁸ and economic dependency. Evidence shows that the wealth, revenue and economic benefits from critical minerals extraction, processing, and trade are not evenly distributed. Rich groups and powerful countries are gaining most, while less underprivileged communities and less developed nations face the lasting negative consequences. For example, even though Namibia, Zambia, and the DRC hold over 30% of the world’s critical mineral deposits, most of the profits go to multinational corporations and mining companies in the Global North.⁴ China, with fewer reserves, earns more from Critical Minerals than these countries combined.⁴

This unfair distribution of critical minerals’ wealth is worsened by the fact that wealthy countries dominate the high-value parts of the supply chain (such as refining, manufacturing, and technology) while poorer, mineral-rich countries are mostly limited to raw materials extraction. This is also because these countries lack the technology, skilled labor, infrastructure, and capital needed to add more value to their extracted resources. As

a result, they miss out on bigger profits and remain stuck in low-value roles. The inequality is further widened when considering that advanced countries maintain firm control over green and digital technologies, finance, and intellectual property and know-how, allowing them to gain most of the economic benefits of the global energy, digital, and sustainability transitions.

For example, the benefits of adopting technologies such as electric vehicles, solar panels, and battery storage are not shared fairly because most people in the Global South and mining communities cannot afford these technologies. This injustice also manifests in the distribution of jobs and employment in critical minerals mining. Local workers in mining regions are often restricted to and engaged in menial roles, hard and dangerous work for low pay, while higher-paying, secure jobs go to their foreign counterparts and experts. Moreover, labor laws in many of the low-income countries are either weak or not enforced due to corruption or weakness of monitoring and enforcing authorities, allowing these unfair practices to continue and further contribute to division and inequality. The persistence of these injustices not only limits income for local workers but also promotes deep labor exploitation, systematically enforces the economic marginalization of economically poor, resource-rich countries, despite bearing the environmental and social costs of critical minerals extraction.

Environmental injustices

Environmental injustices refer to the disproportional and unfair distribution of the environmental harms and benefits of critical minerals extraction and processing; while the negative impacts disproportionately affect marginalized communities and the Global South nations, the environmental benefits are largely enjoyed by wealthier populations and the Global North nations. The environmental impacts of critical mineral extraction fall most heavily on low-income countries, while the benefits—such as lower carbon emissions and cleaner air—mainly go to developed countries in the Global North. This is a clear case of environmental injustice, one of the most visible and harmful forms of inequality in critical minerals extraction that remains

highly overlooked by environmental, climate, and sustainability campaigns and narratives that are normally led by the more politically and economically powerful nations. Mining for critical minerals often causes serious environmental damage, including water pollution, deforestation, loss of biodiversity, soil erosion, and the depletion of natural resources at top of the critical minerals supply chain. So, local communities in the mining regions are often left to suffer the consequences of the global energy and digital transition which is supposed to bring sustainability for all. In regions with weak environmental laws and poor enforcement, mining companies are rarely held accountable. Corruption exacerbates the situation. While the environmental benefits of reducing greenhouse gases through green technologies is global, wealthy nations are the main beneficiaries of the local environmental benefits of adopting these technologies including, but not limited to less air, water, and soil pollution, deforestation, and biodiversity loss. In this case, sustainability for the Global North comes at the cost of environmental destruction borne by countries in the Global South. This reflects deeper global inequalities and highlights the paradox of the global energy, digital, and sustainability transitions: although it aims to fight climate change, biodiversity loss, and pollution, it often creates or worsens environmental injustice.



Raw cobalt bags at an artisanal mining site in Kolwezi, DRC. Photo by Didier Makal/Mongabay.

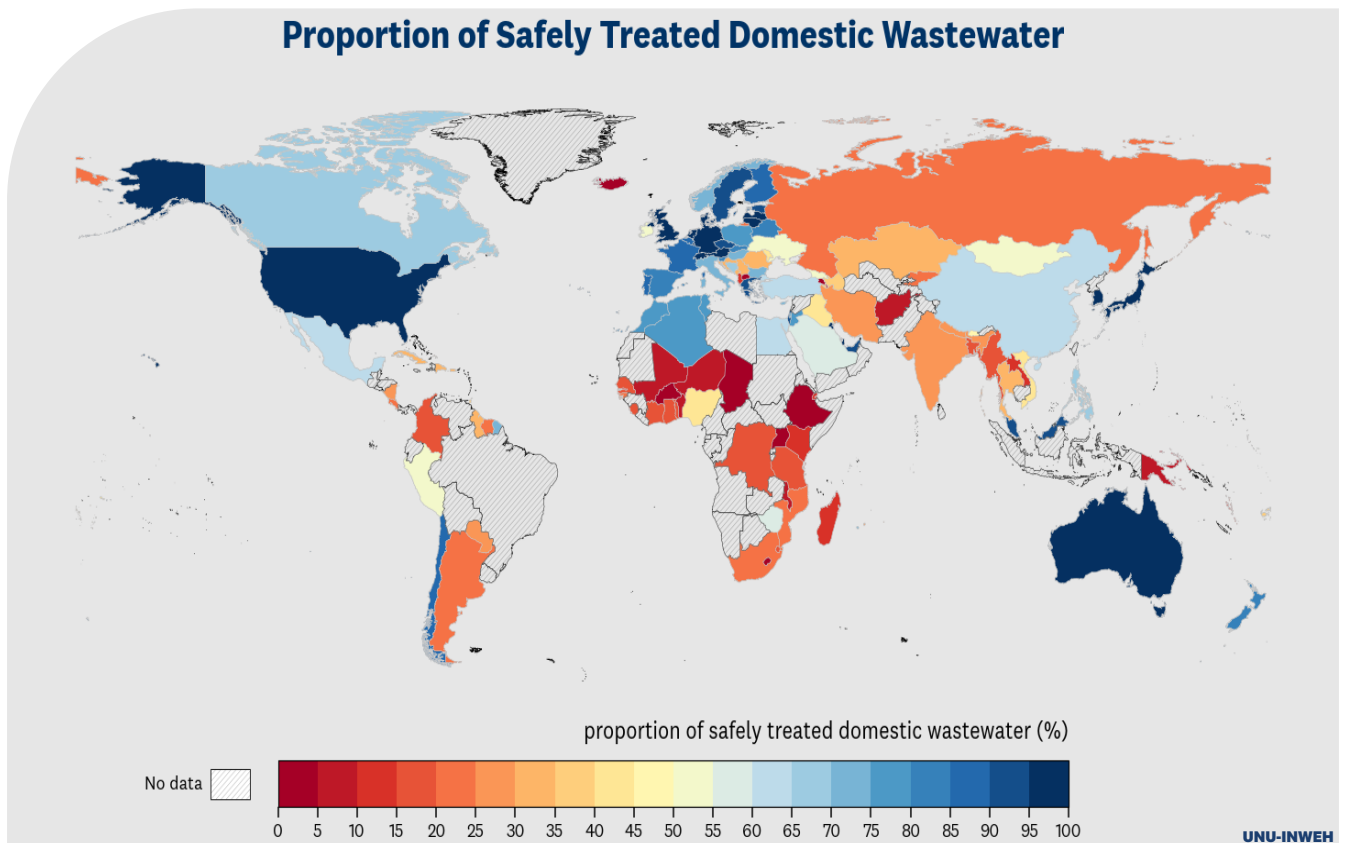


Figure 9. Wastewater treatment, defined under SDG indicator 6.3.1, measures the proportion of domestic and industrial wastewater flows that are safely treated before discharge. The indicator tracks total wastewater generated and the share receiving at least secondary treatment through urban treatment plants, on-site systems, or other approved facilities, following the UN-Habitat, WHO & UNSD methodology.^{37,129}



Aerial view of the Congo River near Kisangani, where pollution and wastewater discharge impact the river. Photo by MONUSCO/ Myriam Asmani/Wikimedia Commons.

Social Injustices

Social injustices in critical minerals supply chains refer to the ways in which the extraction, processing, and global trade exacerbate social inequalities, undermine community rights, and exploit vulnerable populations in the underprivileged communities and the Global South while contributing to social enhancements in the more privileged communities and the Global North. These injustices are especially pronounced among groups already facing systemic marginalization, such as women, children, Indigenous peoples, and rural communities. These vulnerable groups experience the most severe consequences of critical minerals extraction activities.

For instance, women and girls, are often the primary caretakers responsible for accessing water and managing household nutrition. As a result, they are disproportionately exposed to and affected by water pollution caused by mining, which not only threatens their health but also increases their caregiving burdens. Children, too, are deeply impacted by polluted environments and declining agricultural productivity compromise food security, leading to stunted growth and underdevelopment of children due to malnutrition. Simultaneously, Indigenous and rural communities in mining zones regularly face forced displacement, land dispossession, and the loss of their cultural and spiritual heritage because mining operations often encroach on ancestral lands without the free, prior, and informed consent (FPIC) of affected populations. In many cases too, relocation and resettlements are carried out without adequate compensation or viable



Nickel mine at Kouaoua, New Caledonia. Photo by Otto Maderdonner/Flickr.

alternatives for livelihoods.

Beyond the economic toll, these displacements sever local communities' ties to sacred sites such as shrines, ancestral burial grounds, and sacred rivers, leading to deep psychological and cultural trauma. Examples from countries like the DRC, Bolivia, and Argentina highlight these injustices. In these regions, mining activities have displaced communities, sometimes with the backing of state authorities.^{130–133} In several instances when residents resisted relocation, they were threatened and told to accept meager compensation or face eviction without any restitution.^{130,131}

In many regions, the extraction of critical minerals leads to eroding and, in some cases, disrupting of historical and socio-cultural sites and ties with the people.^{4,134} The loss of spiritual and cultural sites contributes to long-lasting social and psychological harm an important but often-overlooked impact of extractive industries.^{76,123} Additionally, mining activities have led to the destruction of farmlands, contamination of water bodies, and displacement of communities that depend on agriculture, fishing, and livestock. This undermines not only local economies but also the social cohesion and cultural identity of affected populations.

Social injustice compounds and intersect with other dimensions of discriminations to undermine health and people's agency to lead healthy lives.¹²⁸ These practices reflect a pattern where local communities bear the brunt of mining's social costs, while the wealthier groups and nations are enjoying the social benefits associated with improved quality of life and living conditions, reduced pollution, and environmental and health improvements. In this sense, despite being framed as a pathway to a sustainable future, the current approach to the energy, digital and sustainability transitions can socially backfire and contribute to social inequalities around the world.

Health injustices

Health injustice across critical minerals supply chains refer to the unfair and disproportional distribution of the health benefits and costs

of extracting critical minerals. Health injustice is a serious and growing concern in the global energy, digital, and sustainability transitions that is closely linked to the pollution caused by mining critical minerals. Evidence from countries like the DRC, a nation that supplies over 70% of the world's cobalt, shows that the health impacts of critical minerals extraction fall most heavily on local communities living near mining sites. These communities often experience high rates of illness and diseases. In many areas, artisanal and small-scale mining exposes workers and nearby residents to dangerous levels of toxic substances such as cobalt dust, uranium, and lead. These materials are known to cause serious health problems, including lung disease, birth defects, and organ damage.^{112,135} Women and children are especially vulnerable. For instance, a study in Lubumbashi, DRC, found that Cobalt concentrations were higher in umbilical cord blood than in maternal blood at delivery, which suggests significant fetal exposure and raises concerns about potential health risks.¹¹⁹

Shockingly, children as young as seven years old work in hazardous conditions without protective equipment—while multinational corporations and wealthy populations around the world continue to profit from their labour. Health risks are not limited to direct contact with toxic minerals. Mining also pollutes the air, soil, and water, leading to increasing health risks in the communities that rely on these resources. In many mining areas, accessing clean water for drinking, farming, cooking, and hygiene is becoming increasingly difficult. The

lack of safe water weakens WASH practices and contributes to the spread of infectious diseases. Women, children, and girls face the most severe health impacts. They are more exposed to polluted environments and are more vulnerable to disease and the effects of poor hygiene. At the same time, they have the least access to healthcare services and support. The psychological burden of living in such conditions is also profound. Knowing that they are suffering to support a “green transition” that benefits others—while their own communities remain poor and underserved—only adds to the mental and emotional stress.

The health inequalities are deeper when considering that many mineral-rich countries have weak and under-resourced public health systems. Clinics and hospitals lack the staff, equipment, and medicines required to treat serious or long-term conditions and diseases caused by exposure to mining pollution. Many of these illnesses need specialized treatment that is only available in well-funded healthcare systems in wealthier countries. This deepens the divide between those who enjoy the health benefits of using life and environmental-improving digital and energy technologies at the end of the critical minerals supply chains and those who bear the health costs at start of the chains. These intersecting forms of inequality reveal that the global energy, digital, and sustainability transitions—while intended to combat climate change, secure sustainability for all, and leave no one behind—can also produce new layers of health disparities for already vulnerable populations.



Trinité Health Center in Kolwezi, DRC. (October, 2023). Photo by Didier Makal/Mongabay.

4. Critical Minerals: Future Actions in Pursuit of Justice



Nickel exploration activities in Weda Bay, Indonesia (2005). Photo by Muhammad ECTOR Prasetyo/Wikimedia Commons.

This UNU-INWEH report highlights a major, overlooked contradiction in the global energy, digital, and sustainability transitions. The demand for critical minerals such as lithium, cobalt, copper, and rare earth elements has risen sharply, tripling since 2010 and projected to quadruple by 2050. These minerals are indispensable for renewable energy systems, electric mobility, and digital technologies needed to meet climate goals and support the Fourth Industrial Revolution. Yet, their extraction is producing significant socio-economic, environmental, and health costs. Lithium mining in arid areas, for example, consumes volumes of water equivalent to the needs of millions of people each year, leading to aquifer depletion, and freshwater contamination. These outcomes affect food security and population health, with women, children, and Indigenous peoples bearing disproportionate burdens. What makes the expansion of extractive activities questionable is that the benefits and costs of extracting critical minerals are not distributed evenly. The richer parts of the world and more privileged population groups are normally the main beneficiaries of extractive activities while the poorer parts of the world and less privileged communities are suffering from their costs. This raises major justice and equity questions that remain unanswered and ignored.



Lithium mine at the Salinas Grandes salt flats in Jujuy Province, Argentina. Photo by Earthworks/Flickr.



Chromite band in gabbro containing platinum, from the USGS mineral collection. Photo by USGS.

Without targeted intervention, the energy, digital, and sustainability transitions risk reproducing extractive colonial patterns, creating “sacrifice zones” where marginalized local communities bear the costs while benefits largely accrue elsewhere. This dynamic undermines progress on key Sustainable Development Goals (SDGs), including water and sanitation (SDG 6), health and wellbeing (SDG 3), poverty reduction (SDG 1), and inequality (SDG 10), and further contributes to supply chain vulnerabilities and geopolitical risks. A Just Transition requires a shift from exploitative extractive practices toward arrangements that embed accountability and equity across the full life cycle of mineral production. This includes ensuring zero net water depletion in extraction, enabling community co-governance of resources, and establishing binding health reparations for affected populations. Advancing these measures will be critical to ensuring that the global energy and digital revolutions deliver not only climate, technological, and computational benefits, but also justice, equity, and long-term resilience and sustainability. The evidence presented throughout this report substantiates three critical and interconnected conclusions.

1. **Water insecurity is a systemic cost of extracting critical minerals:** Critical mineral extraction activities, especially for water-intensive minerals like lithium, are directly depleting and contaminating freshwater resources, jeopardizing the fundamental human right to water, local livelihoods, and regional stability in already water-stressed regions.
2. **Extraction of critical minerals have been associated with unacceptable environmental and health disparities:** The consumption of contaminated water and exposure to heavy metal contaminants is causing a documented surge in public health crises, with the resulting reproductive harm, chronic illness, and psychosocial distress constituting a massive injustice, disproportionately burdening women and children.
3. **Critical minerals governance failures drive injustice:** The current global governance architecture lacks the necessary binding mechanisms to ensure fair distribution of benefits and burdens, with weak local regulation, compounded by the economic power of multinational corporations, preventing mineral-rich nations from moving beyond low-value raw material extraction, reinforcing economic marginalization and environmental injustice.



EXA Infrastructure data center, Frankfurt, Germany. Photo by KaiKemmann/Wikimedia Commons.

Policy Recommendations

To mitigate the injustices and ensure a balanced global transition to sustainability, immediate actions are necessary around key pillars: governance, sustainability, equity, health and social disparities, and collaboration. Specific policies must be tailored to communities, consumers, national and local governments in the Global South, governments in developed and industrialised economies, researchers, and media to address their unique roles and responsibilities. Implementing these policies require urgent, coordinated action, with governments prioritizing policy reforms, corporations committing to ethical practices, and international bodies facilitating knowledge-sharing, to center justice in the critical minerals agenda and transform the global digital, energy, and sustainability transitions into a truly inclusive pathway to sustainability, where no one is left behind.

A. Strengthening International Governance, Accountability and Standards

Mandatory international standards must be established for due diligence, moving beyond voluntary compliance to enforce accountability for human rights and water security globally. Emphasis must be given on the critical need for North-South policy alignment and legal mechanisms that prioritize environmental and ethical sourcing across all supply chains.

- I. **Mandate Full Supply Chain and Financial Transparency:** Laws should be enacted requiring companies and governments to publicly disclose all mining contracts, environmental data, and financial agreements (royalties, taxes) on easily accessible platforms, and require consumer brands to trace and report on mineral origins and supply chains.
- II. **Enforce Mandatory Due Diligence and Ensure Legal Redress:** An international agreement is necessary to harmonize global standards, specifically mandating due diligence on water use and human rights. This framework should integrate existing mechanisms like the OECD Guidance¹³⁶ and the Intergovernmental

Forum on Mining, Minerals, Metals and Sustainable Development (IGF) to create a consistent, mandatory baseline for all actors. Governments should implement and enforce laws requiring companies to identify, prevent, and remedy environmental and human rights abuses across their supply chains. Simultaneously, establishing and supporting accessible legal avenues (including international ones) is necessary for communities to seek justice, file complaints, and receive funding for necessary environmental and health remediation efforts.

- III. **Strengthen Regulatory Frameworks and Independent Oversight:** Governments in the Global South and other critical minerals mining areas of the world should update national mining laws to eliminate regulatory loopholes, legally mandate independent, non-political oversight bodies for compliance, and establish clear mechanisms for communities to file grievances. Government in developed and industrialised economies should use trade policies that enforce strict ethical sourcing and human rights standards across the global mining sector.

B. Empowering Local Communities and Improving Water Security and Environmental Stewardship

Policies should be formulated for proactively safeguarding vital natural resources, such as water and land, from the damaging impacts of mineral extraction. Strong government enforcement of environmental laws with the integration of Indigenous knowledge is required to ensure sustainable management and restoration of affected ecosystems.

- I. **Invest in Low-Water and Eco-Friendly Technologies:** Research and deployment of technologies like direct lithium extraction (DLE) must be encouraged to reduce freshwater use¹³⁷ and other environmental footprints. International funding from bodies like the World Bank's Climate-Smart Mining Initiative can support adoption of such technologies in the mining areas, especially in water-stressed regions.

- II. **Enforce Strict Pollution and Wastewater Controls:** Governments should implement and monitor regulations for wastewater treatment and heavy metal discharge in the mining areas, with mining companies required to adopt zero-discharge systems to protect local ecosystems.
- III. **Integrate Indigenous Knowledge into Resource Management:** Governments should legally empower Indigenous communities to co-develop and lead conservation and resource management plans that integrate traditional ecological knowledge to ensure sustainable, nature-respecting environmental stewardship, including support for Indigenous Protected and Conserved Areas (IPCAs).
- IV. **Proactively Monitor and Enforce Environmental Compliance:** Governments must strictly enforce environmental laws through regular, independent monitoring of water use, waste management, and pollution control. This includes conducting mandatory public testing for heavy metals near sites and allocating public funds for environmental rehabilitation and restoration of degraded lands.



Beryllium ore specimen from the USGS mineral collection, showing its granular, pale structure. Photo by USGS.

Action Agenda for Critical Minerals Stakeholders



Governments in High-demand and Industrialized Nations

- Regulate mineral supply chains by making companies identify, prevent, and fix environmental and human rights abuses
- Fund clean-up and support projects in affected countries, including water purification and health care
- Promote a just transition by ensuring climate and sustainability policies do not repeat past exploitation or colonial patterns
- Use trade policy to require ethical mining practices in any trade deals or import agreements
- Fund R&D for material substitution and advanced recycling
- Fund interdisciplinary research across the critical minerals supply chain and require open data access



Companies/Industries

- Adhere to due diligence laws and provide remedies for abuses
- Invest and deploy zero-discharge and low-water technologies
- Commit to transparent and fair benefit sharing
- Contribute financially to health monitoring and remediation funds
- Design products for longevity and invest in recycling logistics
- Be transparent with company data for verification



Consumers

- Demand transparency from brands and tech companies on mineral sourcing
- Choose ethical products with responsible sourcing certifications
- Advocate for better water stewardship and environmental management
- Support circular economy models: repair, reuse, recycle
- Advocate for strong supply chain laws and corporate accountability
- Learn and share knowledge about environmental and social impacts



NGOs/Civil Society

- Investigate and report on water pollution, health impacts, and rights violations
- Support communities with legal aid, advocacy training, and monitoring tools
- Push for policy reforms enforcing stronger environmental and rights protections
- Connect local struggles to international platforms
- Hold corporations accountable through legal cases or petitions



Media

- Investigate environmental and social mining impacts
- Trace supply chains linking consumer demand to mining harm
- Center community voices and lived experience
- Challenge misleading clean/sustainable mining narratives
- Raise awareness of hidden environmental and human costs

Action Agenda for Critical Minerals Stakeholders



Global Governance/ International Bodies

- Lead international monitoring and regulatory frameworks and ensure legal redress mechanisms are established
- Advocate for inclusive decision making that involves local especially Indigenous people and marginalized groups
- Promote technology transfer and capacity building in the Global South
- Enhance collaborations between global, regional, national and local actors towards ensuring environmental justice
- Advocate and support community empowerment through capacity building and inclusive governance
- Facilitate global and regional partnership that promote Extended Producer Responsibility (EPR) and eco design standards to reduce waste and improve recyclability



Governments in the Global South and Mining Areas

- Enact and enforce national due diligence laws, monitoring water use, pollution, and company compliance
- Strictly enforce policy controls and integrate Indigenous knowledge
- Improve mining regulations to close loopholes and require community consultation and consent
- Use mining revenues to fund health, water, and social services for affected communities
- Prioritize healthcare and public health monitoring for pollution-exposed communities
- Legally enshrine FPIC and establish robust public health systems
- Improve transparency in mining permits, licenses, and revenue management



Local Communities

- Co-develop conservation plans and conduct environmental monitoring
- Hold companies and governments accountable
- Document environmental and health impacts using community tools
- Negotiate benefit-sharing agreements and manage local funds
- Participate in repair/reuse models
- Advocate for inclusive decision-making in EIAs and FPIC processes
- Manage and share community-owned evidence data
- Work with NGOs, media, and researchers to amplify local voices
- Use Indigenous governance in managing land and water



Research and Scientific Communities

- Conduct research on mining–pollution–health–justice linkages
- Study circularity and responsibility across mineral supply chains
- Research benefit-sharing mechanisms and value-retention opportunities
- Co-design research with communities
- Share pollution and health data openly
- Translate science into actionable policy recommendations
- Critically examine sustainability claims using evidence-based analysis

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Figure 10. Summarizes the key actions expected from major stakeholder groups across the critical minerals supply chain. The figure outlines responsibilities for global governance bodies, governments, companies, communities, researchers, civil society, consumers, and the media, highlighting how each actor contributes to strengthening environmental protection, improving social and health outcomes, and advancing more responsible mineral production and use.



Chromium-alum crystals. Photo by Ra'ike / Wikimedia Commons.

C. Ensuring Economic Justice and Equitable Benefit-Sharing

Future policies and actions must ensure extractive industries generate tangible, lasting economic benefits for directly affected communities, not just central governments or corporations. This requires legally mandated and transparent benefit-sharing agreements to channel a fair proportion of mining revenues directly into essential local services and sustainable development.

- I. **Ensure Direct and Transparent Investment in Affected Communities:** Governments should implement legally binding benefit-sharing agreements negotiated directly with affected communities. They must allocate a fair, transparent share of mining revenues (royalty fees, taxes) to fund essential local services (e.g., health, water, energy, education), infrastructure, and vocational training, with oversight by inclusive local committees.
- II. **Provide Compensation and Livelihood Restoration:** Financial compensation for resource loss is insufficient unless paired with robust, long-term programs

to establish alternative livelihoods. These restoration initiatives, like eco-tourism or sustainable farming, are essential to ensure communities can thrive economically after extraction activities cease.

- III. **Foster Social Equity Through Human Rights Protections:** Economic development from mining must be built on a foundation of social equity and rigorous human rights protections for local populations. Communities affected by mining should be empowered through policies fostering social equity, including human rights protections and local engagement to balance extraction with regional economic goals.

D. Establishing Social Justice Safeguarding Human Rights

Frameworks need to be implemented to safeguard community health and human rights. This approach includes strengthening local water infrastructure and healthcare systems to address pollution impacts and strategically supporting grassroots advocacy networks and land defenders.

- I. **Provide Strategic Support for Grassroots Advocacy:** Strategic funding, leadership training, and legal education should be provided to grassroots organizers to build strong local advocacy networks capable of coordinating effective public campaigns and engaging directly with government and corporate institutions.
- II. **Legally Recognize and Enshrine Indigenous Rights and Consent:** National laws must legally enshrine Free, Prior and Informed Consent (FPIC) and recognize customary governance to protect Indigenous land rights and self-determination. This ensures Indigenous Peoples have the ultimate right to approve or reject projects affecting their lands and ensures their formal inclusion in decision-making.
- III. **Mandate Inclusive and Transparent Consultation Processes:** Government should legally mandate transparent and inclusive consultation processes, including translating key documents and conducting public hearings in local languages, ensuring

full participation from vulnerable groups, women, and traditional knowledge holders throughout the Environmental Impact Assessment (EIA) process.

- IV. **Establish Robust Public Health Systems in Mining Regions:** Governments must strengthen local healthcare to treat pollution-related illnesses, requiring companies to contribute financially and conduct mandatory Health Impact Assessments (HIAs) for all major projects focusing on vulnerable groups like women and children. Developing public health databases and training local health workers in environmental risks is vital for tracking and mitigating mining's long-term impacts. Direct funding for local health infrastructure should be provided in mining areas to effectively monitor and treat pollution-related illnesses.



A vertical view of the Mutanda copper-cobalt mine in the DRC. Processed by UNU-INWEH using Sentinel-2 imagery from March 2025.

E. Raising Awareness and Protecting Defenders

- I. **Enhance Media Reporting on Impacts:** Media should enhance reporting on extraction impacts, overcoming sector opacity by investigating human rights abuses, environmental hazards, and community stories to raise awareness and hold stakeholders accountable.
- II. **Protect Defenders and Center Local Narratives:** Protecting environmental and land defenders with legal aid and emergency support networks is critical, as they are often the first targets of opposition. Media and governments must actively promote narratives that reflect the voices, agency, and perspectives of affected communities, not just official statements.

F. Promoting Sustainable Consumption and the Circular Economy

Economic growth should be decoupled from resource extraction by accelerating the shift toward a comprehensive circular economy model. This involves investing heavily in recycling infrastructure and research into material substitution to reduce the global demand for newly mined minerals.

- I. **Incentivize and Demand Ethically Sourced Products:** Consumers and companies must actively favor products certified for low-impact and ethical sourcing to reduce the demand for materials linked to human rights abuses and utilize energy-efficient or recycled materials to minimize the overall environmental footprint of consumer goods.
- II. **Invest in Infrastructure for Product Lifespan Extension:** To reduce reliance on primary extraction, governments and businesses need to invest heavily in the infrastructure required to support robust repair, reuse, and recycling models for electronics and products. Extending product lifecycles through these circular economy measures drastically lowers the need for new raw mineral inputs.

- III. **Fund Research and Prioritize Material Substitution:** Governments in high-demand industrial economies must commit significant funding to research and innovation in areas like material substitution and advanced recycling, thereby decreasing global dependency on high-risk mineral supply chains. Public procurement policies should be utilized to prioritize products containing recycled content, boosting the commercial viability of recovery technologies.
- IV. **Support Recycling and Circular Economy Initiatives:** Global recycling programs must be promoted to decrease reliance on primary extraction, with consumers, especially in the Global North, advocating for policies that mandate ethical sourcing labels on products containing critical minerals.
- V. **Mandate Transparent Product Information and Guarantee the Right to Repair:** Consumer choices must be empowered by making the content and history of products visible and understandable. Governments should also enact policies that require manufacturers to provide consumers with affordable repair services, spare parts, and repair manuals for the full lifespan of products.

G. Generating Knowledge and Sharing Data

Policies should be in place to ensure scientific knowledge is translated into actionable political change by fostering interdisciplinary research on mining impacts. It mandates open data sharing and community-led monitoring to equip advocates with evidence, while empowering media to critically challenge corporate sustainability claims.

- I. **Generate Interdisciplinary Knowledge for Actionable Policy:** Academic institutions and researchers must prioritize integrated, cross-disciplinary research on the water-minerals nexus that holistically examines the links between mining, health, and justice, and actively translate complex scientific findings into clear, actionable policy recommendations for governments and international bodies.

- II. **Promote Research on Supply Chain Risks and Impacts:** Research must be conducted on comprehensive assessments across full supply chains and lifecycles, evaluation of trade-offs, highlighting various forms of injustices and inequalities along the supply chains, and innovations to address such issues.
- III. **Institutionalize Open Data and Community-Owned Evidence:** Research institutions must commit to open data standards for all pollution and health information, ensuring findings are easily accessible to affected communities and advocates. Furthermore, training communities to collect and monitor their own environmental data empowers them to provide respected, localized evidence in legal and policy debates.
- IV. **Amplify Local Struggles and Challenge Dominant Narratives:** Civil society, Media and NGOs must prioritize in-depth investigations into mining's social and environmental impacts, tracing supply chains to connect consumer demand with local harm and actively challenging the notion that resource extraction is an unavoidable cost of the energy, digital and sustainability transitions, while providing media training to empower community storytelling. They should amplify voices from mining communities to hold corporations accountable, while researchers collaborate on policy tools for diverse supply chains.



Copper mine in Toledo, Cebu, with gold, molybdenum, magnetite, and pyrite as by-products. Photo by P199/Wikimedia Commons.

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