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The water footprints of global minerals trade

Why the 'virtual water' use hidden in supply chains is critical to sustainability

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Contents

Summary

- The extraction of minerals central to the technologies driving global economic growth is a significant contributor to water scarcity and pollution, with severe risks to the ecosystems and communities near mining sites. Through the 'virtual water' embedded in minerals and their final products, global supply chains link consumers to the social, environmental and economic impacts of water use in producer countries. This paper explores the steps governments, businesses and consumers can take to protect water resources and boost mineral supply-chain resilience.
- Governments of mineral-rich countries face a difficult choice in balancing competing priorities: safeguarding local communities and the environment on the one hand, while maximizing the economic benefits of mineral resources on the other. Extractive activities can exacerbate existing environmental pressures and water scarcity, increasing the risk of local disputes that can threaten mining operations and the reliability of mineral supply chains.
- Fair virtual water governance is critical to global sustainability efforts and resilient mineral supply chains. Ensuring sustainable, equitable and efficient direct and indirect water use in mining depends on collective action by companies, governments in producer and consumer countries, financial institutions and civil society to strengthen governance and improve water stewardship.
- Inclusive, integrated approaches to water use that reflect the needs of local populations – particularly women, children, Indigenous peoples and other marginalized groups – are most effective in ensuring both local buy-in and stable extractive operations. In contrast, failure to prioritize inclusive engagement can worsen social and systemic inequalities with negative implications for public health, the well-being of neighbouring communities, mining operations and even political stability.
- Strengthened water governance is critical to avoiding financial losses and supply-chain risks associated with water stress – and is a decisive factor in whether mining activity protects the water-security needs of communities, businesses and ecosystems. Such oversight is vital to securing the stability of mining and mineral supply chains and is crucial to societal and community acceptance of mining activities.

- As part of the Fair Water Footprints Initiative (see Box 1), this paper explores the water-related challenges associated with mining and calls for collaborative action on water security between supply-chain actors and host communities for improved water governance. While the current geopolitical context makes progress more challenging, sustainable water governance in the mining sector can be boosted through:
  - Governments requiring comprehensive basin-level, cross-sectoral assessments of water quality and quantity to ascertain the true economic, environmental and social value of water. Authorities should also integrate drought and flood planning into permit systems and strengthen coordination between ministries responsible for water, agriculture, energy, industry, the environment, economic development and finance.
  - Mining companies closely monitoring and reporting on water consumption and contamination in order to calculate water footprints, while implementing robust mining waste management, risk-based due diligence, independent audits to support transparency and accountability, and emergency planning.
  - Collaboration between companies and governments to ensure environmental and human rights safeguards, as well as meaningful participation (including free prior and informed consent) of affected communities and Indigenous peoples in decision-making and benefit-sharing agreements. This cooperation should allow fair and timely access to information and dispute resolution mechanisms.
  - A combination of mandatory international and national measures (such as environmental permitting regulations and directives) and voluntary standards that stipulate inclusive stakeholder engagement, expand transparency and accountability, promote best practice and drive improvements in the sustainability, equitability and efficiency of activities related to mining.
  - Investors and financiers integrating water and climate risks into more reliable and comprehensive credit and market models, stress-testing portfolios against water scarcity, pollution and extreme weather events and making operational resilience a condition of capital supply.
  - A whole-of-supply-chain approach with producer- and consumer-country governments, downstream industries and consumers demanding responsibly sourced minerals that conform to social, environmental and mining waste management standards, while investing in recycling and circularity to reduce primary demand.

Preface

At the 2021 United Nations Climate Change Conference, COP26, a coalition of 23 governments (including the host nation, the UK), businesses and civil society organizations signed the **Glasgow Declaration for Fair Water Footprints for Climate-Resilient, Inclusive, and Sustainable Development**. Signatories resolved to 'take transformative action for fair water footprints which will have durable benefits for our communities, ecosystems, and economies, and help to achieve Sustainable Development Goal 6 (SDG 6): Ensure availability and sustainable management of access to water and sanitation for all by 2030'.[1] This minilateral, multi-stakeholder initiative aims to demonstrate commitment to good water stewardship, promote best practice, and have its principles considered and taken up in a broader set of forums, including existing multilateral processes.

The Glasgow Declaration is based on shared recognition that the 'water footprints' of consumer society, economic activity and international trade are tightly connected, including through global supply chains. Signatories identify the shared obligation of consumers, producers, trading partners, industry, investors, financiers and retailers to ensure sustainable and equitable water use.

Water governance is not only a matter for those concerned with local river basin management or in-country economic development. It is a cross-border and global issue affecting multiple aspects of international relations.

Underpinning this commitment is the principle that water governance is not only a matter for those concerned with local river basin management or in-country economic development, as is often perceived to be the case. It is also a cross-border and global issue affecting multiple aspects of international relations. The consequent need for a global approach to water governance is exemplified by the fact that the water footprints of many high-income nations are 40–80 per cent external, meaning that such countries are highly reliant on water use elsewhere in the world for the production and delivery of imported goods.[2]

Trade potentially allows for a more balanced use of the world's water resources by enabling water-scarce countries to access water-intensive products from water-plentiful countries and regions – and for both parties to profit from the exchange. However, in reality, a combination of overextraction of resources, underpricing and low regulation in many countries often results in water-intensive products coming from water-scarce and/or climate-vulnerable regions. In such

1 Fair Water Footprints (2021), 'The Glasgow Declaration for Fair Water Footprints for Climate-Resilient, Inclusive, and Sustainable Development', p. 3, https://fairwaterfootprints.org/resource/declaration-in-full/fwf_glasgow_declaration_rebrand_proof_01.
2 Chapagain, A. K. and Mekonnen, M. M. (2023), 'Understanding the water footprints of the Global North and dependency on water use within the Global South', Water Witness International, https://fairwaterfootprints.org/resource/towards-fair-water-footprints-understanding-the-water-footprints-of-the-global-north-and-dependency-on-water-use-in-the-global-south.

cases, the production of commodities for export can have significant negative consequences for water resources in the exporting country, including by causing water pollution, diversion and depletion, and by reducing society's resilience to climate and biodiversity crises. Globally, the safe limits for freshwater use have been transgressed, increasing the risk of unmanageable instability in the hydrological system.[3]

In this context, the Glasgow Declaration defines 'fair water footprints' as those that meet five social and environmental sustainability criteria: zero water pollution; sustainable water withdrawals and equitable allocation of water; protection of nature; access to safe water, sanitation and hygiene; and resilience to droughts, floods, climate variability and water conflict (see Box 1).[4]

This research paper is one of a series of three that explore the water-related impacts of global trade in different sectors. The sectors are: food and agriculture; textiles; and metals and minerals. These sectors were chosen because all have significant international water footprints, are often particularly thirsty and polluting, and are increasingly affected by (and themselves affect) climate change and other environmental challenges. Each paper provides a concise overview of what is known about that sector's water footprint, highlighting the global trade dependencies between producer and consumer countries. The papers provide an overview of how global trade is contributing to, or undermining, prospects for realizing the Glasgow Declaration's ambition for 'fair water footprints' in each sector. At the same time, they examine how trade partnerships can serve countries' strategic security interests and – at both national and multilateral levels – strengthen water-related policy and practice.

Chatham House is a member of the Fair Water Footprints partnership[5] alongside CDP, the International Institute for Environment and Development, Water Witness International, and the UK government's Foreign, Commonwealth and Development Office (FCDO). Together we are working with signatories to the Glasgow Declaration to drive progress towards the ambitions of the declaration.

Box 1. Fair water footprints

The Glasgow Declaration defines fair water footprints[6] as direct and indirect water use that demonstrates:

— **Zero water pollution.** No adverse impacts on the aquatic environment or other water users or functions arising from wastewater discharges. Diffuse pollution is controlled to improve the aquatic environment.

3 Richardson, K. et al. (2023), 'Earth beyond six of nine planetary boundaries', *Science Advances*, 9(37), https://doi.org/10.1126/sciadv.adh2458.
4 Fair Water Footprints (2021), 'The Glasgow Declaration for Fair Water Footprints for Climate-Resilient, Inclusive, and Sustainable Development'.
5 Fair Water Footprints (undated), 'Frequently asked questions', https://fairwaterfootprints.org/faqs-glasgow-declaration-for-fair-water-footprints.
6 Fair Water Footprints (2021), 'The Glasgow Declaration for Fair Water Footprints for Climate-Resilient, Inclusive, and Sustainable Development'.

- **Sustainable withdrawal and equitable allocation of water.** Water abstractions and use are within sustainable limits and do not compromise the human right to water, adversely affect downstream needs, or imperil the water security of future generations. This criterion is focused on 'blue water' impacts – that is, those affecting streams, rivers, lakes, aquifers etc. (see Box 2 for definitions of terminology).
- **Protection of nature.** Ecosystems and their services are valued and protected; nature-based and regenerative solutions are prioritized. This criterion encompasses 'green water' (essentially, soil moisture – see Box 2) and blue water uses.
- **Access to safe water, sanitation and hygiene.** Within the workplace, all workers have access to reliable and safe drinking water, toilets and washing facilities; collective action reaches communities in need.
- **Resilience to droughts, floods, climate variability and water conflict.** Effective planning, policy and investment support resilience to climate change, water-related disasters and conflict.

01 Introduction

Mining and processing of minerals can consume and pollute vast quantities of water. Improving the sustainability, efficiency and equitability of water use should be a priority for governments, the private sector and civil society in order to protect local communities, the environment and global supply chains.

Minerals are essential building blocks for the technologies and energy systems that power the global economy. These raw materials are the primary inputs for consumer digital products, such as smartphones and laptops, and communication networks. Electrical transmission, critical infrastructure, and national security and defence also depend on these minerals. Crucially for the energy transition, these commodities are fundamental in low-emissions technology, such as wind turbines, solar panels and electric vehicle (EV) batteries (Figure 1). The rise in demand for minerals will require global expansion of mining and likely entail increased pressure on water resources. Governments and corporate actors alike should urgently consider and adopt more sustainable, efficient and equitable practices to mitigate water risks to operations and raw material supply, while protecting local communities and the environment.

Mining and processing of minerals can cause severe environmental damage, not least to fresh water, a vital resource affected by rising consumption, contamination and climate change worldwide. The mining sector consumes and pollutes vast amounts of water globally. Environmental, social and governance (ESG) data show that global water withdrawals by major mining companies increased by about 10 per cent between 2021 and 2024.[7] This is a concerning rise, particularly when mining activity is set to grow and expand into water-scarce and environmentally fragile regions, such as the Cajamarca region in Peru, where gold and copper are mined, and the Pilbara

7 McLoughlin, B. (2025), 'Water withdrawals in mining increase by 10% in three years', *Mining Magazine*, 20 November 2025, https://www.miningmagazine.com/environment/news-analysis/4523521/water-withdrawals-mining-increase; Jalali, S., Nour-Mohammad, M. and Fakhroleslam, M. (2025), 'Toward circular water economy in mineral processing: Technological state of the art review and challenges analysis', *Sustainable Production and Consumption*, vol. 46, https://www.sciencedirect.com/science/article/abs/pii/S2214993725005019.

region in Australia, known for iron ore. Pollutive waste streams can occur due to the leaching of toxic chemicals and heavy metals, which can be released into surface water and groundwater through untreated highly saline or acidified wastewater and leaching from heaps of ore and tailings (the leftover waste material once ores have been removed). Furthermore, higher-temperature water from mining activities and processing operations, including material removal and processing (e.g. cooling), can impact downstream aquatic ecosystems.

Water is embedded as 'virtual water' in raw materials through the fresh water consumed and polluted in the extraction and processing of minerals. Pressures on water sources from overexploitation, pollution and changes in climate and hydrological systems mean that addressing water scarcity is emerging as a critical social, economic and environmental concern.[8] This presents challenges for water security, environmental sustainability and global trade of minerals and manufactured products (see Preface for background on the concept of 'fair water footprints'). Accounting for the virtual water hidden in traded products (see Box 2 for definitions), as well as understanding the impacts of water footprints on local communities and producers, exporters and importers, is vital for improving the sustainability of water use and to secure resource supplies. This embedded water connects producers of metals and minerals to the downstream supply chain and consumers, who may not be aware of the impact their purchases have in other parts of the world.

An unsustainable water footprint from the mining sector (see Box 2) can severely impact the water security of Indigenous peoples and local communities, which in turn can affect a mining company's social licence to operate. Excessive water footprints can have negative impacts on local access to clean water for household uses, which would particularly impact women, girls, the elderly and other marginalized groups who tend to be responsible for the collection and use of water for domestic purposes. This strain on water can also affect livelihoods dependent on access to fresh water such as fishing, aquaculture or agriculture. Leakage from tailings dams (structures built to store waste materials) can contaminate water for both human and ecosystem uses while deforestation can reduce flood resilience.

Resulting changes to hydrological patterns can lead to the degradation of rivers, lakes, wetlands, aquifers and coastal waters that are crucial for maintaining the health of entire ecosystems – impacting aquatic biodiversity, wildlife and plant species – and ecosystem services that are central to local communities and Indigenous ways of life. Mismanaged and overexploited water resources, which breach ecological limits and exceed the sustainable use of local resources, can compromise the water security of populations who already live on the frontlines of intensifying environmental degradation and climate change.

8 United Nations University Institute for Water, Environment and Health (UNU-INWEH) (2026), *Global Water Bankruptcy: Living Beyond Our Hydrological Means in the Post-Crisis Era*, report, Ontario: UNU-INWEH, https://dx.doi.org/10.53328/INR26KAM001.

This paper discusses the production of minerals and metals and their dependence on local water resources. Fossil fuel extraction, cleaning, processing, refining and combustion account for the largest impacts on water from mined commodities.[9] This type of mining and extraction is deserving of separate treatment and falls outside the scope of this analysis. The focus in this paper is on industrial mining for metal ores and minerals that are used in the production of traded inputs for technology, energy and defence sectors, where demand is expected to increase significantly. This research includes case studies of three water-vulnerable countries – Indonesia, South Africa and Chile – and explores the water security of each as well as the social and environmental impacts mining has on local water resources. The paper discusses several mandatory and voluntary measures that can address gaps in the management of local water resources and virtual water trade. It also identifies places where mining sector policy (in exporting and importing regions) is attempting to address water-related risks.

Box 2. A note on terminology

'Blue', 'green' and 'grey' water

Discussion of the hydrological cycle and freshwater use typically categorizes fresh water according to source or pollution, with each category assigned a colour:

Blue water refers to surface and groundwater stores and flows (springs, rivers, lakes, reservoirs, aquifers). Groundwater includes both renewable and fossil resources, the latter of which are not replenished by the hydrological cycle; this means that fossil water extraction results in a permanent depletion of that resource.

- **Withdrawal of blue water** includes both 'consumptive' and 'non-consumptive' uses:
  - Consumptive water use is defined as use that results in the water not returning to its source. This includes evaporation, the incorporation of water into products, and the return of water to another catchment or sea. Only consumptive use is measured in water footprints.
  - Non-consumptive water use results in water being removed but later returned to its source. This is also known as 'return flow' and is not measured in water footprints.
- **The sustainability of blue water footprints** is measured with reference to water depletion. The measurement reflects the ratio between the blue water footprint (see definition of 'footprints' below) in an area/period and the total available volume of blue water in the same area/period.

Green water refers to soil moisture, which forms the evaporative flow for crop growth or for maintaining natural ecosystems.

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9 Vengosh, A. (2023), 'Lecture on "The global water footprint of fossil fuels"', Eawag Swiss Federal Institute of Aquatic Science and Technology, 2 March 2023, https://www.eawag.ch/en/info/agenda/detail/?chash=285235180241c12be01c0be6283a9bc1&tx_sfpevents_sfpevents%5Bevent%5D=2224&cHash=621354a8448a1600be51287ef52631be.

Grey water refers to the volume of fresh water required to dilute pollutants or to meet water quality standards for a specific pollutant load. If that volume of water is not available (and in the absence of other treatment), then water quality standards are violated.

Water footprints

Water footprints are an indicator of freshwater use. They consider both direct and indirect water use by consumers and producers of goods or services. The water footprint of a consumer of specific goods or services is defined as the total volume of fresh water used to provide the goods or services consumed;[10] the water footprint of a producer of goods and services is defined as the total volume of fresh water used to provide those goods or services. Water use is measured in terms of water volumes consumed (i.e. evaporated or incorporated into a product) and/or polluted per unit of time.

A water footprint can be calculated for a particular product (e.g. for a type of food, textile or critical material, etc.) in relation to any well-defined category of consumer of that product (e.g. an individual, family, village, business, city, province, state or nation), as well as in relation to any producer of that product (e.g. a public organization, private enterprise or economic sector).[11]

Where direct and indirect water footprints are distinguished from one another, the direct water footprint is the water consumed or polluted by the specific actor or in the specific activity in question, whereas the indirect water footprint is the water consumed or polluted in the inputs or supply-chain activities prior to the relevant actor or activity.

A water footprint is a geographically explicit indicator and can be used to understand the water interdependencies that arise between countries through the export and import of goods. However, because it is a purely volumetric measurement, it does not directly convey the sustainability or impacts on water scarcity of water consumption. But the water footprint can be used alongside other measures to ascertain whether water use in a specific location – whether affecting an aquifer, river basin or entire nation – is sustainable. In this way, the impacts of water use on environmental water requirements and water quality can be assessed.

Virtual water

'Virtual water' is the amount of water (blue and/or green) required to produce a good or service, including all the production steps. This is also referred to as the water 'embedded' within a product. For a given product, its blue/green virtual water content is the same as its blue/green water footprint, but the concept of virtual water applies only at the *product* level whereas a water *footprint* can also measure water consumption by a company, region or country, etc. A water footprint can also quantify water pollution impacts. This is known as the 'grey water' footprint. The concept of virtual water is often used in trade contexts, with 'virtual water trade' referring to the exchange of goods and services based on their virtual water content.[12]

10 Service-related water footprints have historically reflected small amounts of water consumption, but may become a more meaningful category given that data processing (e.g. for artificial intelligence) entails very high levels of water consumption.
11 Fair Water Footprints (2021), 'The Glasgow Declaration for Fair Water Footprints for Climate-Resilient, Inclusive, and Sustainable Development'.
12 Global Commission on the Economics of Water (2024), *The Economics of Water: Valuing the Hydrological Cycle as a Global Common Good*, Paris: OECD/Global Commission on the Economics of Water, https://watercommission.org/#report.

02 Water in mining operations

The various methods and techniques used to mine and process minerals have different water requirements and impacts. Consumption and pollution of water resources can have cascading negative outcomes on society, the environment and the economy.

Role of water in minerals production

Water is an essential input to the mining and processing of minerals. Mining operations depend on water for activities such as minerals extraction, ore washing and flotation (where ore is separated from waste), ore processing and refining (Table 1). Water is also used in comminution practices,[13] dust suppression, slurry transport, and the use of hydropower for electricity generation to power equipment. The waste from extraction, washing and processing of minerals and metals is typically stored in tailings dams. The approach to tailings management affects a mining operation's water balance – a method of accounting for water flows into and out of a mine – due to evaporation, seepage or discharge.[14] If infrastructure is not designed and maintained properly, dam failures can release harmful waste with devastating consequences (Box 3). Even after a mine is no longer in use, it can still pose a long-term threat to the quantity and quality of surface water and groundwater.

13 The crushing and grinding process to reduce the size of ores and release valuable minerals from surrounding rock.
14 Northey, S. A. et al. (2016), 'Water footprinting and mining: Where are the limitations and opportunities?', *Journal of Cleaner Production*, vol. 135, pp. 1098–1116, https://www.sciencedirect.com/science/article/abs/pii/S095965261630912X?via%3Dihu.

Box 3. The Fundao and Brumadinho tailings dam disasters

In 2015, the collapse of the Fundao tailings dam at the Samarco Mariana iron ore mining complex in Brazil led to the deaths of 19 people, the displacement of hundreds of citizens and the destruction of homes, wildlife and critical infrastructure. The failure of this dam released 39.2 million cubic metres of toxic waste into the River Doce. This pollution was carried over 650 kilometres to the mouth of the river on the Atlantic Ocean. The tailings dam collapse caused one of the largest environmental disasters in Brazil's history.[15] The event had devastating impacts on local and Indigenous communities such as the Krenak, Tupiniquim, Guaranis and Quilombola populations (Afro-descendant communities, predominantly composed of the rural and urban Black population).[16] In 2024, the Samarco mine owners, Brazilian mining company Vale and Australia's BHP Billiton, agreed a compensation package with the Brazilian government in excess of $30 billion.[17]

In January 2019, Vale's Corrego do Feijão mine in Brumadinho, Brazil, also suffered a tailings dam failure releasing 11.7 million cubic metres of mining waste, leading to the deaths of 272 people and large-scale environmental damage. This tailings dam disaster had disproportionate impacts on vulnerable communities, specifically riverside dwellers and artisanal fishermen who were already socially and economically marginalized.[18] In 2021, Vale agreed to pay $7 billion in compensation.[19] A 2024 study shows that five years after the disaster, its effects on water quality in the Paraopeba River 'are still notorious and persistent'.[20]

In both cases, legal proceedings continue. In the case of Brumadinho, criminal charges are being levied against not only personnel from Vale but also some staff of the German auditing company Tüv Süd, which certified the stability of the dam despite documented structural hazards.[21]

Surface mining, the most common extraction method, covers an area of about 1 per cent of the globe, but it can have an extensive impact on biodiversity, water resources and nearby communities that extend beyond the immediate

15 UN Environment Programme (2018), 'Dam or be Damned: Mining safety under scrutiny', 22 March 2018, https://www.unep.org/news-and-stories/story/dam-or-be-damned-mining-safety-under-scrutiny.
16 Da Costa Oliveira, P. et al. (2020), 'Traditional knowledge of Fishers *versus* an environmental disaster from mining waste in Central Brazil', *Marine Policy*, 120, https://www.sciencedirect.com/science/article/abs/pii/S0308597X20301585?via%3Dihub; Jalali, Nour-Mohammad and Fakhroleslam (2025), 'Toward circular water economy in mineral processing: Technological state of the art review and challenges analysis'.
17 BHP (2024), 'BHP Brasil reaches settlement with Public Authorities in Brazil for reparation of Samarco's Fundão dam failure', press release, 25 October 2024, https://www.bhp.com/news/media-centre/releases/2024/10/bhp-brasil-reaches-final-settlement.
18 Ferreira, C., Guimarães, V., Castro, P. and Petesse, M. (2024), *Mining Disaster in Brumadinho (Brazil): Social Vulnerability from the Perspective of the Fisherman Community*, Research Paper, SSRN, 4 July 2024, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4885713.
19 Vale (2025), 'Brumadinho', https://vale.com/esg/brumadinho.
20 Mello, C. C. S., Leão, M. M. D. and Amorim, C. C. (2024), 'Five years after the Brumadinho dam collapse: Evaluation of water quality based on combined analysis of land use and environmental data', *Science of The Total Environment*, 957, https://doi.org/10.1016/j.scitotenv.2024.177619.
21 ECCHR (2026), 'Criminal trial opens in Brazil against Vale and TÜV Süd employees: Corporate accountability under scrutiny', press release, 23 February 2026, https://www.ecchr.eu/en/press-release/prozessauftakt-gegen-mitarbeiter-von-vale-und-tuev-sued-mangelnde-unternehmensverantwortung-vor-gericht.

mine site.[22] The water intensity of a mine, as well as the water management tools and principles used, are largely dependent on the size of the mine, the proximity to water sources, the mining method, and the geochemistry and minerology of the orebody. Mines can alter hydrological cycles through deforestation and other land-use changes, withdraw large quantities of water from surface and groundwater sources, release or disrupt sediments that change water quality and the geomorphology of river systems, and produce wastewater that contains heavy metals such as lead, cadmium and mercury that contaminate water bodies (Box 4).

Mining activities can contribute to water scarcity and pollution of rivers, lakes and aquifers, both locally and downstream of a mine, resulting in mineral rich regions facing varying degrees of water overexploitation and contamination along with the intensifying effects of climate change. While some negative effects of mining on rivers, lakes and aquifers may be temporary, in other cases, they may last beyond the life of a mine.

Box 4. Acid mine drainage

Sulphide-bearing material from mining can oxidize when it comes into contact with water and oxygen to form sulphuric acid. The resulting acidic water contains heavy metals that, if uncontrolled, can run off into streams or rivers, or leach into aquifers during various stages of the mining process. This is known as acid mine drainage and it is one of mining's most serious threats to water,[23] contributing to the grey water footprint as it pollutes fresh water. The resulting lower pH of local waterways creates unsuitable conditions for aquatic fish and plants, humans and wildlife, and can have dangerous consequences for communities, wildlife and agriculture where soil sterilization impacts water quality, plant growth and crop yields.[24] Furthermore, acidic wastewater can erode the banks of rivers and cause the build-up of sedimentation that can clog riverbeds, smother vegetation and organisms, and degrade wildlife habitats.[25]

The risk and damage to water from acid mine drainage can endure due to the non-degradative nature of heavy metal contamination. Uncontrolled run-off and leaching of wastewater also represent a loss of valuable resources for the mining industry – in terms of water and minerals – that could be recovered to make the process more efficient and sustainable.[26]

22 United Nations Environmental Programme (2024), *Critical Transitions: Circularity, Equity, and Responsibility in the Quest for Energy Transition Minerals*, working paper, United Nations Environmental Programme, https://wedocs.unep.org/bitstream/handle/20.500.11822/46623/critical_transitions.pdf?sequence=3&isAllowed=y.
23 Earthworks (2005), 'Hardrock Mining: Acid Mine Drainage', 16 December 2005, https://earthworks.org/wp-content/uploads/2021/09/FS_AMD.pdf.
24 Centre for Environmental Rights (undated), 'Acid Mine Drainage', https://cer.org.za/programmes/mining/environmental-issues/acid-mine-drainage#:~:text=Its%20effects%20are%20devastating%20as,of%20derelict%20and%20ownerless%20mines.
25 Akcil, A. and Koldas, S. (2006), 'Acid Mine Drainage (AMD): causes, treatment and case studies', *Journal of Cleaner Production*, 14(12–13), pp. 1139–1145, https://doi.org/10.1016/j.jclepro.2004.09.006.
26 Masindi, V. et al. (2022), 'Challenges and avenues for acid mine drainage treatment, beneficiation, and valorisation in circular economy: A review', *Ecological Engineering*, 183, https://doi.org/10.1016/j.ecoleng.2022.106740.

Table 1. Mining stages and water impacts

Production stage		**Description**	**Minerals and metals (non-exhaustive list)**	**Water interactions and uses**	**Water impacts and risks**
Extraction and mining					
Surface mining	Open-pit/cast mining	The surface mining technique is used for mineral or ore deposits found close to the surface of the Earth and over a large area.[27] This is the predominant method of mineral extraction.	Iron, molybdenum, uranium, copper, diamonds, gold, silver, phosphate.	• Water can flow into the mine from rainfall, surface run-off, nearby rivers or lakes and is removed through diversion, storage or pumping. • Removal and treatment of water to minimize contamination.[28]	• Disruption to surface water and groundwater flow. • Waterway contamination as a result of soil erosion and degradation. • Acid mine drainage. • Deforestation affects soil moisture retention (green water), replenishment of materials and landslide risk (see Indonesia case study).[29]
	Placer mining	Process of obtaining mineral deposits from loose river sediments.	Gold, platinum, diamonds, tin, titanium, iron.		• Increased sediment load can negatively affect a river's shape and flow as well as contaminate aquatic systems. • Acid mine drainage. • Thermal pollution.
Underground mining		Extracts minerals deposited below the Earth's crust by digging tunnels and shafts beneath the surface. The process is used when materials are deep and concentrated.	Diamonds, coal, iron.	• Pumps groundwater out to maintain water balance.	• Acid mine drainage. • Groundwater contamination and flow disruption.
In-situ leaching (ISL)/ solutions mining		A dissolving solution (a mix of water and chemicals) is pumped into the orebody from a series of injection wells, and is then pumped out, together with salts dissolved from the orebody.	Lithium, gold, silver, copper, sediment-hosted uranium, salt, potash, magnesium, sulphur.	• Uses water to dissolve soluble minerals in a brine that is pumped to the surface.[30]	• Brine leakage and dissolved materials contaminate groundwater in leaching process.
Dredging		Process of excavating sediment, minerals and other materials from underwater environments such as rivers, lakes and seabeds. Dredging is also used in tailings management to remove waste material from a body of water.	Mineral sands and gravel, alluvial diamonds, gold, rare earth minerals.	• Mining operations take place underwater. • Water is used as a medium to transport materials in a liquid slurry mix through pipes.	• Sediment dispersion affects water quality. • Increased turbidity from sediment. • Water quality impacts caused by contamination from trapped pollutants. • Dredging changes water flow with potential to increase erosion causing flood risk.

27 Anglo American (undated), 'Open-pit mining definition', https://www.angloamerican.com/futuresmart/stories/our-industry/mining-explained/mining-terms-explained-a-to-z/open-pit-mining-definition.
28 SRK Consulting (undated), 'Managing Surface Water in Open Pit Mines: An experience from India', https://www.srk.com/en/projects/india-surface-water-control.
29 Rudge, S. (2025), 'Open-Pit Mining: The Top 3 Pros and Cons Explained', M&M Today, 9 April 2025, https://m-mtoday.com/news/open-pit-mining-the-top-3-pros-and-cons-explained.
30 Laurence, E. (2023), 'Solution Mining Guide', The Assay, https://www.theassay.com/articles/the-assay-insights/solution-mining-guide.

Production stage	Description	Minerals and metals (non-exhaustive list)	Water interactions and uses	Water impacts and risks
Ore washing and flotation	Critical pre-treatment step where mineral ores are washed to remove sediment and impurities. Flotation – often the most water-intensive part of the process – can follow ore washing and is used to separate different minerals based on their properties.	Gold, iron, tin.	• High-pressure water is used to remove impurities from raw ore. • Ore is crushed and mixed with water. Chemicals are then added to make minerals hydrophobic and support flotation to the surface.	• Produces wastewater contaminated with heavy metals e.g. lead, cadmium, mercury and other pollutants. • Siltation of water bodies, reduced water flow downstream.
Processing				
Separating minerals from waste materials through milling, beneficiation, smelting and refining.[31]	Typically consists of separating minerals from waste materials and separating concentrate values, which requires water to support a number of processing activities including cooling machinery.	All minerals and industrial rocks.	• Water is used to purify and isolate minerals from rock, in the mixing and transportation of particles[32] and in dust suppression.	• Acid mine drainage. • Water overconsumption can reduce groundwater quality and availability. • Improper disposal of liquid waste contributes to local water pollution.
High-pressure acid leaching	A process to extract minerals from orebodies by using elevated temperatures (250°C), elevated pressures and sulphuric acid.[33]	Nickel, cobalt.	• High water consumption. • Water is an essential chemical ingredient in the leaching process.[34]	• High risk of soil and groundwater pollution.
Tailings dams	The extraction, washing and processing of minerals and metals produces waste that is stored and managed in tailings dams.	All mining	• Approach to waste management will influence water balance due to evaporation, seepage, discharge or physical entrainment in tailings material. • Water evaporation from tailings storage facilities.[35] • Water seepage into surface and groundwater from tailings ponds.[36]	• Tailings dam failures can pollute water and degrade ecosystems with additional impacts on human lives (see Box 3).
Mine closure	Process of ceasing mining operations, followed by decommissioning and rehabilitating a site.	All mining	• Water table stabilization (rewatering). • Water quality assurances.	• Acid mine drainage.

Source: Compiled by the authors.
Note: There are indirect water uses that are not captured by this table that include human water consumption at the mine, water used in electricity production and chemical inputs, among other indirect uses.

31 Beneficiation includes crushing, grinding, gravity concentration and flotation concentration.
32 Ranchod, N. et al. (2015), 'Assessing the blue-water footprint of an opencast platinum mine in South Africa', Water SA, 41(2), pp. 173–79, https://www.scielo.org.za/pdf/wsa/v41n2/16.pdf.
33 Nickel Institute (2025), 'Nickel Industry – Part 3 Processing nickel laterites, high-pressure acid leaching', 7 March 2025, https://nickelinstitute.org/en/blog/2025/march/nickel-industry-part-3-processing-nickel-laterites-high-pressure-acid-leaching.
34 Ranchod et al. (2015), 'Assessing the blue-water footprint of an opencast platinum mine in South Africa'.
35 Ibid.
36 Ibid.

Environmental and social impacts

According to a 2024 UN Environment Programme report, which referenced a study of 1,400 mines around the world, 20 per cent of mining operations were in areas where water consumption exceeded 80 per cent of the total water available. The number of mining companies operating in water-scarce locations is expected to rise.[37] As previously mentioned, mineral extraction can reduce flows and groundwater levels, cause contamination, contribute to habitat fragmentation and loss of biodiversity, and increase competition for water with other sectors and users. For example, lithium mining in Chile has led to groundwater depletion, soil contamination and impeded local farmers' access to water.[38] The continued unsustainable use of water in mining and the impact on natural resources limits the capacity of communities to adapt to climate change and droughts. For example, degraded ecosystems cannot filter and regulate floodwaters or retain soil moisture, increasing vulnerability to floods and droughts.

The environmental impacts of mining can also exacerbate social issues and inequalities. Access to water sources for local communities can be diminished as water is diverted to mines or polluted as a result of mining activities. For example, in the Democratic Republic of the Congo (DRC), acid mine drainage, among other mining-related water risks, has polluted local drinking water.[39] A March 2024 report by RAID and AFREWATCH found that industrial cobalt and copper mining in the DRC was negatively affecting neighbouring communities,[40] which suffered from health issues that they believed were due to water contamination from local mines. Women and children were found to suffer disproportionately from skin, respiratory, digestive and reproductive issues as they are often responsible for a household's collection and use of water e.g. for cooking, cleaning and laundry, resulting in more exposure to contaminants in polluted water.[41] In addition, as water sources become polluted, women and girls may need to go longer distances to obtain water.[42]

Women are also often excluded from consultation and community engagement processes carried out by mining companies, or it is simply the case that the contributions of men are prioritized over those of women. This bias against women can affect the implementation of grievance mechanisms – processes through which local communities are, in theory, able to report concerns to a mining company.[43]

Community engagement strategies can assist mining companies to mitigate social and environmental impacts related to water, but miners would likely need to be compelled to take action, either through government regulation, consumer

37 UNEP Finance Initiative (2024), *Climate Risks in the Metals and Mining Sector*, Geneva: United Nations Environment Programme, https://www.unepfi.org/wordpress/wp-content/uploads/2024/05/Climate-Risks-in-the-Metals-and-Mining-Sector-1.pdf.
38 UNCTAD (2020), 'Developing countries pay environmental cost of electric car batteries', 22 July 2020, https://unctad.org/news/developing-countries-pay-environmental-cost-electric-car-batteries.
39 RAID (2024), *Beneath the Green: A critical expose of the impact of copper and cobalt mining on the right to water in the DRC*, London: Rights and Accountability in Development, https://raid-uk.org/wp-content/uploads/2024/03/Report-Beneath-the-Green-DRC-Pollution-March-2024.pdf.
40 Ibid.
41 Ibid.
42 Ibid.
43 BMZ (2024), *A Guide to Gender and Mining: Issues, Actors and Initiatives*, Bonn and Berlin: Federal Ministry for Economic Cooperation and Development, https://rue.bmz.de/resource/blob/209750/guide-to-gender-and-mining.pdf.

pressure or local community protests that threaten operations. Benefit-sharing agreements (BSAs), which typically establish how the economic returns of resource extraction are shared between communities and mining companies, are a potential option for addressing community interests.[44] When well designed and implemented, BSAs can address social and environmental risks while maintaining the economic value of mining. For example, in the US state of Montana, the Stillwater Mine’s 25-year-old Good Neighbor Agreement sets water quality metrics that are more robust than those required by state and federal legislation.[45] The agreement commits the company to transparency through operational monitoring, data access and annual performance audit requirements. As a result, the local community and the mining company have been able to collaborate to protect land and water resources.

BSAs remain a voluntary exercise on the part of mining companies and are most successful in jurisdictions that already have a strong governance and regulatory environment, which may limit their applicability in environments where governance is weak or lacking capacity. Third-party frameworks for the sector, which are discussed in Chapter 5, are also useful tools to prevent social and environmental impacts in mining by promoting best practices.

Financial losses

Unsustainable water practices can impact production capacity and cause financial losses for mining companies. Corporate disclosure data submitted to the independent environmental reporting organization CDP[46] reveal that the main causes of water-related financial impacts for mining companies are flooding, extreme weather events, increased water scarcity, drought and declining water quality – all of which are worsened by unsustainable water use.[47]

These can result in a range of impacts including stalled production, fines and penalties, damage to company assets and disrupted sales.[48] For instance, a major drought in Chile caused Antofagasta Minerals to reduce production by around a quarter at its Los Pelambres mine in early 2022.[49] In 2023, a copper mine in Australia had to cease operations when record levels of rainfall overwhelmed operations.[50] The financial losses can be significant. Severe flooding in Germany in 2021 caused nearly $32 billion in damages and production losses at mines and metals plants.[51] With the expectation of increased demand for minerals, the possibilities of disruptions to supply due to unsustainable water practices and extreme weather are a real risk for the local economy, mining companies,

44 Adebayo, E. and Werker, E. (2021), ‘How much are benefit-sharing agreements worth to communities affected by mining?’, *Resources Policy*, 71, https://www.sciencedirect.com/science/article/pii/S0301420720309983.
45 Riedl, D., Saha, D. and Balleny, L. (2026), ‘A New Era of US Mineral Mining Must Put Communities First’, 5 January 2026, https://www.wri.org/insights/us-critical-mineral-mining-community-impacts.
46 CDP is a global non-profit that runs the world’s only independent environmental disclosure system for companies, capital markets, cities, states and regions to manage their environmental impacts.
47 CDP (2019), *In Too Deep: Analysis for institutional investors of critical water security issues facing the metals and mining sector*, London: CDP Worldwide, https://assets.ctfassets.net/v7uy4j80khf8/4gzTz6ww2XYRPYQ6pG6jvl/67f17dbd8dc13246e473601341fd81c2/in-too-deep.pdf.
48 Ibid.
49 UNEP Finance Initiative (2024), *Climate Risks in the Metals and Mining Sector*.
50 Ibid.
51 Ibid.

the downstream supply chain and consumers.[52] Planning for floods and droughts in coordination with public authorities and local communities is critical to reduce economic losses and social and environmental impacts from these extreme events.

According to a 2023 CDP study, 90 per cent of water use takes place in the upstream part of the value chain, and a similar trend can be observed in the mining sector.[53] Downstream buyers can coordinate with mining companies to evaluate water-related risks, using risk assessment tools like the WWF Water Risk Filter or World Resource Institute's (WRI) Aqueduct Water Risk Atlas. Buyers setting water-use and water pollution targets for their suppliers can increase transparency and support more informed and sustainable water use. This in turn can reduce the risk of financial impacts to operations and downstream consumers. The mining sector's increasing exposure to water-related impacts requires sustainable and forward-looking solutions rather than reactive and mitigation-oriented strategies.

Water-related trade challenges

In recent years, governments in the Global North have taken more aggressive action to secure supplies of minerals to meet demand, a pattern that is expected to continue as the energy transition progresses. Water scarcity and pollution have typically been understood as regional or basin-level issues, with responsibility sitting almost exclusively with host national and local governments. Water dependent supply chains like those of critical minerals reflect a very different reality. Given that most minerals are transported long distances and pass through multiple production and assembly supply-chain stages, from the mine to their final use in consumer and industrial products, it is important to consider the virtual water embedded in minerals and their end-use products when assessing the sustainability, resilience and social impacts of supply chains.

Consumer-country governments have a vested interest in supporting sustainable water practices in mining regions because water risks, from over-abstraction and pollution, can disrupt supply chains and threaten the supply of industrial and consumer goods. As more countries strive to secure access to these minerals, trade agreements will play an important role. Shared responsibility between producer and consumer countries could enable a more sustainable approach. Trade agreements can be leveraged to push for greater water stewardship, biodiversity protection and environmental resilience, in addition to social and economic development objectives. This can complement other policy measures like value addition in producer countries and supply-chain security for consumer countries. If trade agreements fail to address water security in an inclusive manner, this will undermine the resilience of communities involved in, and proximal to, mining and mineral processing activities and potentially introduce additional social, environmental and political challenges that could disrupt continuity of supply.

52 S&P Global (2026), ''Substantial Shortfall' in Copper Supply Widens as the Race for AI and Growing Defense Spending Add to Accelerating Demand, New S&P Global Study Finds', 8 January 2026, https://press.spglobal.com/2026-01-08-Substantial-Shortfall-in-Copper-Supply-Widens-as-the-Race-for-AI-and-Growing-Defense-Spending-Add-to-Accelerating-Demand,-New-S-P-Global-Study-Finds.
53 CDP (2023), *The Global Water Report 2023*, London: CDP Worldwide, https://www.cdp.net/en/insights/global-water-report-2023.

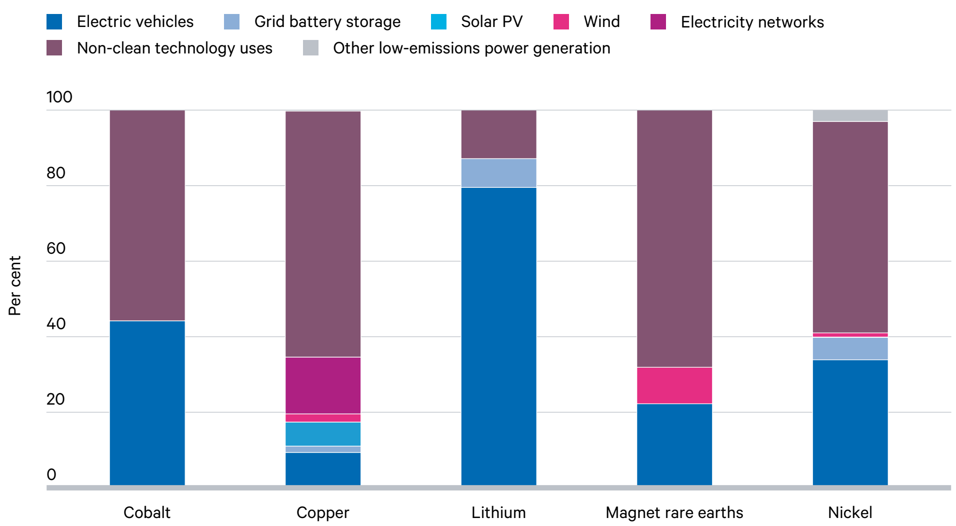
03 Critical minerals

As demand accelerates for minerals vital to clean energy technology, consideration of fair water footprints can prevent social inequities and environmental damage in mining regions, which is essential for a just green transition.

Demand for critical minerals

The demand for minerals essential to the energy transition is expected to rise dramatically over the next two decades.[54] In recent years, there has been a significant increase in the consumption of critical minerals and metals including copper, iron ore, manganese, cobalt, lithium and nickel. This need comes from clean technology sectors such as modern electricity networks, renewables and EVs, as well as non-clean technology sectors such as electronics, defence and construction (Figure 1).

Figure 1. Projected end-uses for selected critical minerals by 2050



Source: International Energy Agency (2025), 'Critical Minerals Dataset', https://www.iea.org/data-and-statistics/data-product/critical-minerals-dataset (accessed Mar. 2026).

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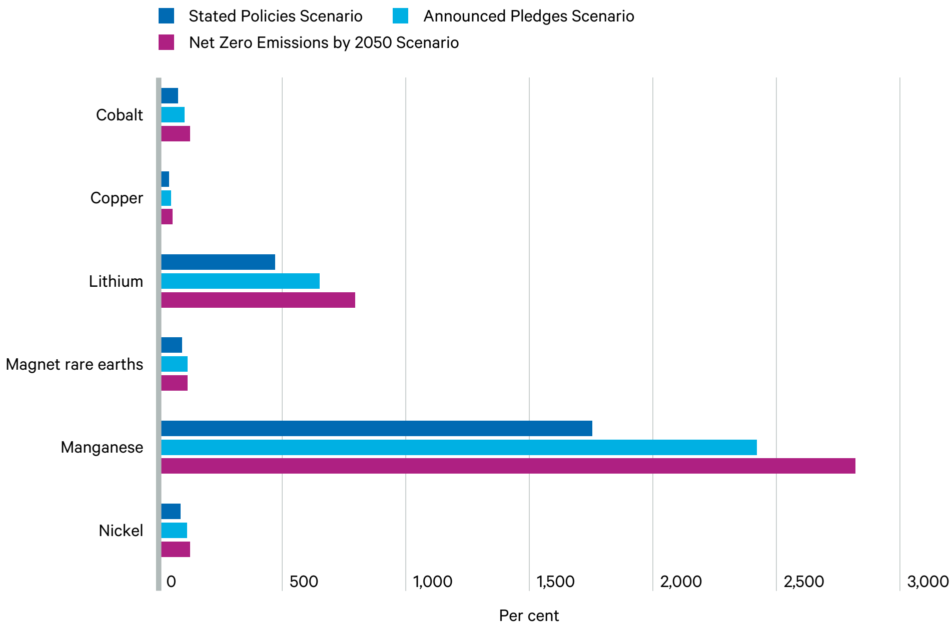
54 European Commission (2020), *Critical Raw Materials for Strategic Technologies and Sectors in the EU: A foresight study*, Luxembourg: Publications Office of the European Union, https://rmis.jrc.ec.europa.eu/uploads/CRMs_for_Strategic_Technologies_and_Sectors_in_the_EU_2020.pdf.

According to the International Energy Agency's (IEA) 2025 *Global Critical Minerals Outlook*, demand for raw materials is projected to increase significantly by 2050 under current policies: based on those that have been announced and those that would be required for a net zero global economy (figures 2 and 3). At the time of writing, the highest rates of demand come from Japan, China, Europe and North America. The growing market for highly profitable mineral supply chains incentivizes the scaling up of mining operations. As mining production ramps up to meet this appetite, it is important to implement fair water-use practices that enable the secure supply of critical minerals, protect the environment and recognize the rights of local communities.

As mining production ramps up to meet growing demand, it is important to implement fair water-use practices that enable the secure supply of critical minerals, protect the environment and recognize the rights of local communities.

As developed countries and companies act to secure their supply of critical minerals, it will be beneficial for them to have a robust understanding of the local context where the minerals are mined and processed. This is not an idealistic consideration, but essential for the secure and stable production and supply of critical minerals.

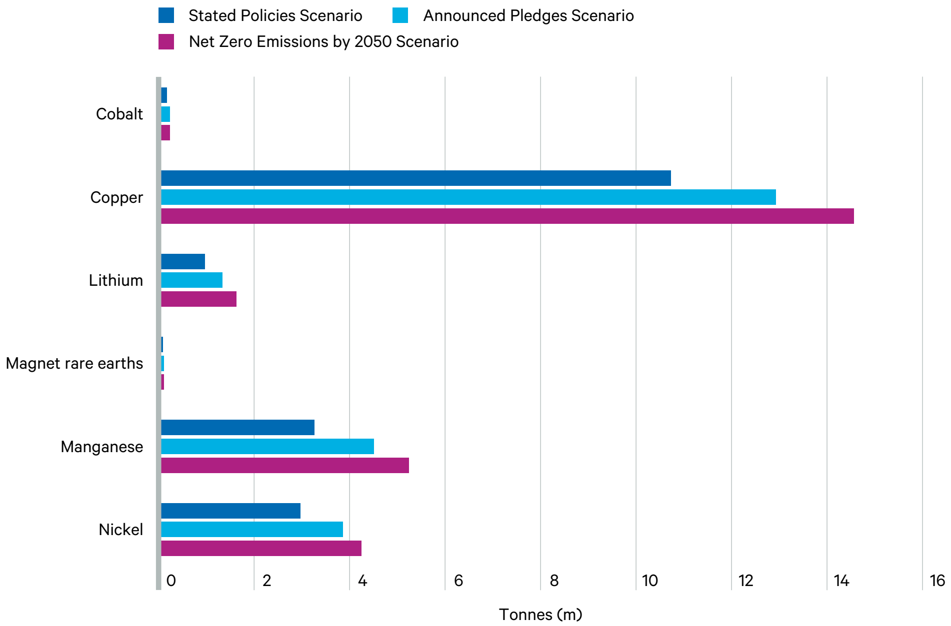
Figure 2. Projected increases in annual demand for critical minerals between 2024 and 2050



Source: International Energy Agency (2025), 'Critical Minerals Dataset'.

Australia, Chile, Indonesia, Russia, Peru, China, South Africa, the US and, more recently, Greenland, are just some of the regions that are primed for further exploration and extraction due to their potential mineral reserves, existing production capacity and increased investment (Figure 4). The scramble to secure supplies of critical minerals has propelled high-consuming countries to forge deals with producing countries endowed with mineral reserves. This is taking place in a context of fragmented trade and security dynamics in which the US, Europe and other developed and emerging economies seek to reduce reliance on China, the leading supplier of critical minerals and renewable energy technology. Meanwhile, China itself is also increasing its acquisitions of mines abroad – with 2024 marking its highest ever annual overseas mining investment at $22.1 billion.[55]

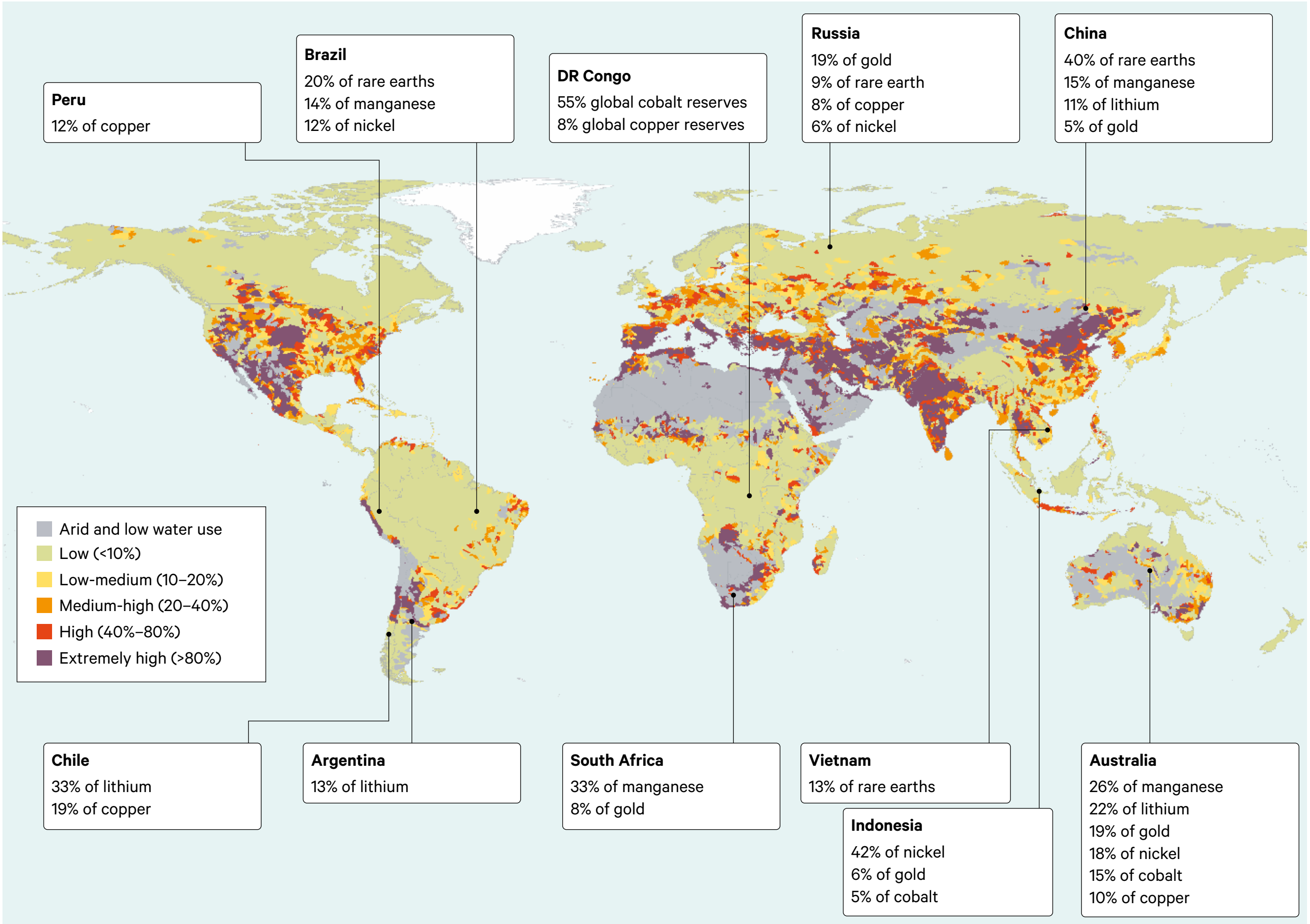
Figure 3. Total physical amounts of mined material required to meet 2050 goals under IEA scenarios



Source: IEA (2025), 'Critical Minerals Dataset'; IEA (2025), 'Critical Minerals Data Explorer', https://www.iea.org/data-and-statistics/data-tools/critical-minerals-data-explorer.
Note: Manganese figures relate to demand for clean energy applications only, not total demand.

55 Hodgson, C., Hook, L. and White, E. (2025), 'China snaps up mines around the world in rush to secure resources', *Financial Times*, 6 July 2025, https://www.ft.com/content/51c2016a-28f3-4600-9e08-a491410d34a9.

Figure 4. Countries with the largest reserves of cobalt, copper, gold, lithium, manganese, nickel and rare earths.



Source: World Resources Institute (2025), 'Aqueduct Water Risk Atlas > Baseline Water Stress', https://www.wri.org/applications/aqueduct/water-risk-atlas (accessed 15 Jun. 2026); Ritchie, H. and Rosado, P. (2024), 'Which countries have the critical minerals needed for the energy transition?', Our World in Data, 10 April 2024, https://ourworldindata.org/countries-critical-minerals-needed-energy-transition.
Note: Percentages refer to countries' share of global reserves; reserves are defined as 'how much known and assessed mineral deposits can be mined economically with current technologies and market conditions'. The underlying map shows predicted water stress by 2050 under a business-as-usual scenario.

According to data from the United States Geological Survey and the WRI Aqueduct Water Risk Atlas,[56] at least 16 per cent of global critical mineral mines, deposits and districts located on land are in areas facing high or extremely high baseline water stress.[57] The growing demand for these minerals is expected to lead to a 20 per cent increase in critical mineral mines located in areas with high or extremely high water stress by 2050.[58]

56 WRI (2021), 'Aqueduct Water Risk Atlas', 6 October 2021, https://www.wri.org/data/aqueduct-water-risk-atlas.
57 Lakshman, S. (2024), 'More Critical Minerals Mining Could Strain Water Supplies in Stressed Regions', 10 January 2024, World Resources Institute, https://www.wri.org/insights/critical-minerals-mining-water-impacts#:~:text=Glencore%2C%20the%20largest%20cobalt%20mining,water%20targets%20and%20stewardship%20strategies.&text=There%20are%20a%20number%20of,targets%2C%20implementation%20strategies%20and%20policies.
58 Ibid.

The water footprint of critical minerals

Water footprints are not extensively monitored in the mining sector, which limits assessments of risks to populations, businesses and supply chains, as well as comparability between mines and mining practices. As a measure of the water consumption and pollution of a product across its life cycle (Box 2), water footprints could be beneficial in the mining sector to keep track of and account for the environmental, social and economic impacts that stretch across complex and often opaque supply chains. Understanding the water footprint of minerals production and processing, and the basin characteristics of mining locations, is necessary to accurately assess the sustainability of minerals production and the stability of supply.

Consider the supply chain of a lithium-ion battery, which has several applications most notably in EVs and electricity grid operations. A lithium-ion battery contains at least nine key minerals, among them are nickel, graphite, cobalt, lithium and manganese. An average lithium-ion battery for an EV with a 60 kilowatt hour (kWh) capacity can contain 6 kilograms (kg) of lithium, 20 kg of copper, 8 kg of cobalt and 52 kg of graphite, this is in addition to another 99 kg of other critical minerals, including nickel and manganese – all of which have significant water footprints.[59]

Some of the most economically viable deposits of lithium are found in Argentina, Bolivia, Chile and Australia, where water resources are under threat of over-abstraction. Water is used to extract, pump and process lithium from brine resources. A recent study in Argentina's salt flats noted that the water footprint of battery-grade lithium carbonate can range from 50,000 litres (50 cubic metres) to 2 million litres (2,000 cubic metres) per tonne (mostly made up of grey water footprint and indirect blue water footprint).[60] Large-scale extraction of brine from saline aquifers interrupts the equilibrium of groundwater supplies. Additionally, fresh water is typically drawn from ground and surface water sources that local communities rely on for agricultural and domestic uses.[61]

Over 70 per cent of the global supply of cobalt, another key battery component, is produced in the DRC, where acid mine drainage (Box 4) has contaminated local drinking water and contributed to 14 mining-related water pollution incidents.[62] Meanwhile, the single largest component in lithium-ion batteries, graphite, requires approximately 9,930 litres of water per tonne.[63] These figures suggest that the water footprints of minerals and their final products are significant, but this does not paint the full picture. Water is also directly and indirectly consumed and polluted in the processing, refining and manufacturing stages in different

59 Bhutada, G. and Alexander, A. (2022), 'The Key Minerals in an EV Battery', 2 May 2022, https://elements.visualcapitalist.com/the-key-minerals-in-an-ev-battery.
60 Diaz Paz, W. F. et al. (2025), 'The water footprint of lithium extraction technologies: Insights from environmental impact reports in Argentina's salt flats', *Heliyon*, 11(4), https://doi.org/10.1016/j.heliyon.2025.e42523.
61 Quintanilla, V., Cañas, D. and Oviedo, J. (2025), 'Why lithium mining in the Andean salt flats is also called water mining', 27 March 2025, https://aida-americas.org/en/blog/why-lithium-mining-andean-salt-flats-also-called-water-mining.
62 Camarillo, I. (2024), *Trade and Critical Minerals: The Deadly Cost of Cobalt Mining in the Congo*, Public Citizen, https://gtwaction.org/the-deadly-cost-of-cobalt-mining-in-the-congo.
63 Gunda, T., Valdez, R., Houck, D. and Linville, L. (2023), *Critical Role of Water for Energy Transitions Technologies: A Literature Review*, Sandia National Laboratories, https://www.osti.gov/servlets/purl/2430129.?utm_.

geographies from where minerals are first extracted, further increasing the water footprint of the final product.

Variations in geography, water sources, water management and operational configuration,[64] as well as the lack of comprehensive and standardized water inventory data make it difficult to apply the water footprint metric. It is important for mining companies to address these challenges to more accurately understand the sector and its water footprint – in terms of green, blue, grey, direct and indirect water use. Widespread application of the water footprint could inform decision-making about the sustainability of minerals, support the development of governance mechanisms and provide an evidence base that permits stakeholders to push for technologies and management schemes that reduce environmental and social impacts. However, this requires greater corporate transparency and political will at both the national and international levels.

In 2018, of the companies that reported to CDP, 91 per cent disclosed that they had encountered some form of risk from water-related stress, the financial cost of which was collectively valued at $24.9 billion.

So, who is responsible for the water footprint of commodities mined for use in technology? Globalized supply chains mean that the locations of the mining and processing of ores, and the manufacture of intermediary parts and end products can be spread out across several countries. A number of companies will be involved along this chain and demand for the final product may be thousands of kilometres from production. Failing to sustainably manage the consumption and quality of water along the supply chain can jeopardize the social licence of companies to operate, especially when mining and processing activities are taking place in water scarce regions. In 2018, of the companies that reported to CDP, 91 per cent disclosed that they had encountered some form of risk from water-related stress, the financial cost of which was collectively valued at $24.9 billion.[65]

Responsibility for the policy, regulatory and enforcement context in which companies invest and operate chiefly lies with governments at each stage of the supply chain. Producer governments, in particular, face competing priorities of maintaining environmental and social standards and ensuring local climate resilience, all while making their resources profitable and attractive to global markets. There are, however, also risks for retailers and importer governments, in terms of both reputation and supply-chain interruptions relating to the social and environmental impacts of the misuse of water.

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64 Rodríguez, J. E., Razo, I. and Lázaro, I. (2023), 'Water footprint for mining process: A proposed method to improve water management in mining operations', *Cleaner and Responsible Consumption*, 8, https://www.sciencedirect.com/science/article/pii/S2666784322000481.
65 UNEP Finance Initiative (2024), *Climate Risks in the Metals and Mining Sector*, Geneva: United Nations Environment Programme, https://www.unepfi.org/wordpress/wp-content/uploads/2024/05/Climate-Risks-in-the-Metals-and-Mining-Sector-1.pdf.

04 Country case studies

The water-related risks from mining are negatively impacting local communities and the environment. With the prospect of mining growth, producer countries must evaluate how high operating standards for mining activities can boost resilience.

Indonesian nickel

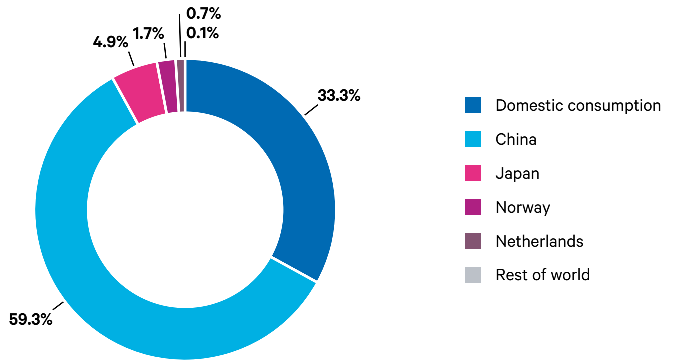
Indonesia is the world's largest producer of nickel, accounting for 50 per cent of global production.[66] The country possesses 42 per cent of global reserves, and nickel makes up a significant portion of the mining sector, which contributed 12 per cent of Indonesia's GDP in 2022.[67] Indonesia's government hopes that revenue from the nickel industry for EVs and stainless-steel production will replace the country's projected declining fossil fuel revenues, due to the energy transition. The national strategy aims to triple nickel production by 2030, and the government has committed to securing over $30 billion in planned investments from Chinese companies, mainly in high-pressure acid leaching (HPAL) and smelting facilities that process nickel ore and concentrates.[68]

66 United States Geological Survey (USGS) (2024), 'Nickel', https://pubs.usgs.gov/periodicals/mcs2024/mcs2024-nickel.pdf.
67 Ibid.; IEEFA (2024), *Indonesia's Nickel Companies: The Need for Renewable Energy Amid Increasing Production*, Lakewood, OH: Institute for Energy Economics and Financial Analysis, https://ieefa.org/sites/default/files/2024-10/IEEFA%20Report%20-%20Indonesia%27s%20nickel%20companies%20need%20RE_Oct2024.pdf.
68 IEA (2022), *An Energy Sector Roadmap to Net Zero Emissions in Indonesia*, https://iea.blob.core.windows.net/assets/b496b141-8c3b-47fc-adb2-90740eb0b3b8/AnEnergySectorRoadmaptoNetZeroEmissionsinIndonesia.pdf.

Nickel production is also likely to grow due to the mineral's use in green transition technologies. In 2022, nickel batteries – particularly lithium-nickel-cobalt-manganese batteries – accounted for an estimated 60 per cent share of the global EV battery market.[69] Nickel is central to Indonesia's ambition to become a global EV battery hub.

To support domestic value addition, the government banned the export of raw nickel ores and concentrates in 2020.[70] Companies were instead encouraged to build domestic HPAL plants to process nickel into EV material. This has been successful in attracting – mainly Chinese – investment, for large industrial complexes. Exports of nickel-based products in 2023 were predominantly bound for China ($4.91 billion), Japan ($1.28 billion), Norway ($3.97 million) and Netherlands ($1.55 million).[71]

Figure 5. Destinations of Indonesia's nickel production, 2023



Source: United Nations Comtrade (undated), 'TradeFlow', https://comtradeplus.un.org/TradeFlow (accessed 22 May 2026).

Mining operations in 29 small Indonesian islands are dominated by nickel, according to local non-governmental organization JATAM (Mining Advisory Network).[72] Indonesia's largest nickel reserves are located on the island of Sulawesi, which is rich in biodiversity and rare, endangered species. Sulawesi is also one of Indonesia's most vulnerable areas to climate change with longer dry periods and wetter rainy seasons. It is predicted that water scarcity will worsen as mining activity increases.[73]

Despite the opportunities afforded by the nickel sector's growth prospects, Indonesia faces many water-related challenges including water scarcity and pollution, as well as insufficient access to water, sanitation and hygiene (WASH)

69 International Energy Agency (2023), *Global EV Outlook 2023*, International Energy Agency, https://iea.blob.core.windows.net/assets/dacf14d2-eabc-498a-8263-9f97fd5dc327/GEVO2023.pdf.
70 International Trade Administration (2024), 'Indonesia Country Commercial Guide', https://www.trade.gov/country-commercial-guides/indonesia-mining.
71 United Nations Comtrade (undated), 'TradeFlow', https://comtradeplus.un.org/TradeFlow (accessed 22 May 2026).
72 Naim, A. et al. (2021), *Small Island of Indonesia, the Land of Mines: The Report on the Destruction of the Entire Bodies of Small Islands of Indonesia by Mineral and Coal Miners*, Jakarta: Jaringan Advokasi Tambang [Mining Advocacy Network], https://jatam.org/wp-content/uploads/2021/05/Small-island-book.pdf.
73 Schwerdtner Manez, K., Husain, S., Ferse, S. and Manez Costa, M. (2012), 'Water scarcity in the Spermonde Archipelago, Sulawesi, Indonesia: Past present and future', *Environmental Science and Policy*, 23, pp. 74–84, https://doi.org/10.1016/j.envsci.2012.07.004.

services for its people. Water stress is a prominent challenge in the islands of Java, Bali and Sulawesi – where nickel mining is largely concentrated – and in the province of East Nusa Tenggara. Industrial demand for water nationwide is expected to quadruple from 9 billion cubic metres in 2015 to 36 billion cubic metres by 2045.[74] Where over-abstraction goes unaddressed, there will likely be more severe consequences of floods due to land subsidence, which could reduce GDP by up to 1.42 per cent by 2045.[75]

Indonesia's expansion of nickel mining and domestic processing will likely increase impacts on fresh water. The use of open-pit mining can cause deforestation, which increases the likelihood of erosion and sedimentation that can choke rivers. The impact of this mining method has been severe. The International Union for Conservation of Nature (IUCN) points to government data showing that in 2022 there were at least 21 floods and mudslides in Southeast Sulawesi. Prior to the increase in open-pit mining, there were two or three such incidents per year between 2005 and 2008.[76] HPAL smelters (used for battery-grade nickel) generate acidic wastewater containing sulphuric acid.[77] This process can create up to 100 tonnes of toxic tailings for every tonne of nickel produced.[78]

Indigenous peoples appear to have suffered disproportionately due to deforestation, displacement, and direct effects on their health and livelihoods from polluted water.

Meanwhile, coal-powered smelters (common in Morowali, central Sulawesi) discharge cooling water at high temperatures, endangering coral reefs and fish stocks. In addition, coal-fired power also remains a pollution problem with flue water adding to downstream pollution.

The environmental impacts of the nickel industry exacerbate human rights violations and poor environmental regulation. The Morowali Industrial Park, on Sulawesi Island, covers an area of over 3,000 hectares and is expanding. The area is also prone to heavy flooding, worsened by the loss of forest cover.[79] The tailings dams are vulnerable to collapse as happened in March 2025, when a landslide

74 World Bank (2021), *Indonesia: Vision 2045 – Towards Water Security*, Washington, DC: World Bank, https://documents1.worldbank.org/curated/en/099300112012118742/pdf/P1707570a8b2460d40bca000d934cd70259.pdf.
75 Ibid.
76 Lotulung, G. (2024), 'Nickel, forests and fishers: a story from Sulawesi', IUCN National Committee of the Netherlands, 14 November 2024, https://www.iucn.nl/en/blog/nickel-mine-exploitation-threats-to-sulawesis-natural-environment.
77 Sangadji, A. (2024), *HPAL: A New Challenge for the Environment in Indonesia – A Focus on Nickel as a Raw Material of Electric Vehicle Batteries*, Jakarta: The Action for Ecology and People Emancipation (AEER), https://www.aeer.or.id/wp-content/uploads/2025/02/Arinto-Sangadji-HPAL-dalam-Industri-Nikel-Feb-2025-ENG_compressed.pdf.
78 Jong, H. N. (2025), 'Landslide deaths again highlight safety failures in Indonesia's nickel industry', 1 May 2025, https://news.mongabay.com/2025/05/landslide-deaths-again-highlight-safety-failures-in-indonesias-nickel-industry.
79 Auriga Nusantara (2024), 'Nickel Rush in Indonesia: The blind spots of the green transition', presentation made in Transition Minerals meeting, 2024: https://auriga.or.id/cms/uploads/pdf/presentation/2/1/nickel_rush_in_indonesia_the_blind_spots_of_the_green_energy_transition_2_en.pdf; Jong (2025), 'Landslide deaths again highlight safety failures in Indonesia's nickel industry'.

following heavy rain killed three workers.[80] In 2021, interviews with residents of Bete Bete village revealed that they faced a clean water shortage for two months due to mining activities.[81]

Nickel mining impacts on water are having a sustained negative effect on the livelihoods of farmers and fishermen. In Kabaena island in Southeast Sulawesi, for example, nearby nickel production is degrading marine ecosystems used by the Bajau sea tribe in Kokoe, who have reported an 80 per cent decline in octopus catch.[82] Indigenous peoples appear to have suffered disproportionately due to deforestation, displacement, and direct effects on their health and livelihoods from polluted water.[83] Although investment is increasing in nickel mining, Action for Ecology and People's Emancipation, a non-profit organization, noted an increase in poverty in the nickel-producing areas of Morowali. Furthermore, in interviews local women have highlighted the fact that mining has had particularly detrimental effects on land- and marine-based livelihoods and domestic needs.[84]

Many of the countries in the nickel supply chain that benefit from this virtual water trade are less water-stressed than Indonesia. Governance improvements are necessary to address worsening social and environmental impacts of water usage, but rather than being purely a domestic issue for Indonesian stakeholders, all actors in complex global nickel supply chains have a responsibility for, and vested interest in, improved water governance and stewardship.

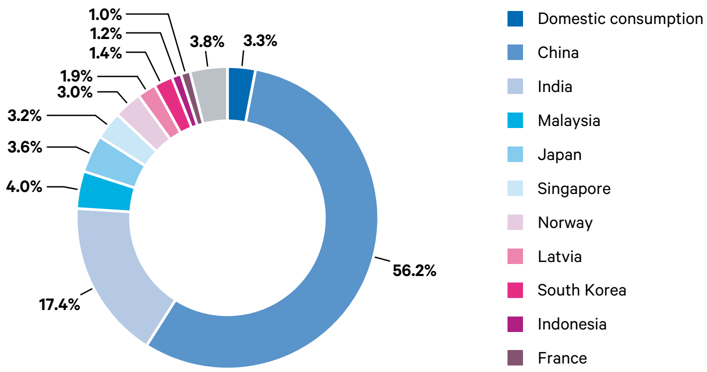
South African manganese

South Africa is rich in mineral resources, boasting some of the world's largest reserves of gold, platinum, iron ore, chromium and manganese.[85] Mining contributed approximately 6 per cent to the country's GDP in 2024.[86] South Africa has the largest proven reserves of manganese, at around 33 per cent of global resources.[87] The country's manganese production accounts for 40 per cent of the global export market.[88] In 2024, South Africa exported nearly 24 million tonnes

80 Jong (2025), 'Landslide deaths again highlight safety failures in Indonesia's nickel industry'.
81 Sangadji (2024), *HPAL: A New Challenge for the Environment in Indonesia – A Focus on Nickel as a Raw Material of Electric Vehicle Batteries*.
82 Jong, H. N. (2025), 'Nickel boom on an Indonesian island brings toxic seas, lost income, report says', Mongabay, 23 July 2025, https://news.mongabay.com/2025/07/nickel-boom-on-an-indonesian-island-brings-toxic-seas-lost-incomes-report-says.
83 Sawal, R. (2023), 'Catatan Akhir Tahun: Karut Marut Hilirisasi Nikel, Persulit Hidup Masyarakat, Lingkungan Makin Sakit' [Year-End Notes: The Chaos of Nickel Downstream Processing Complicates People's Lives, and the Environment Becomes Worse], Mongabay Indonesia, 30 December 2023, https://mongabay.co.id/2023/12/30/catatan-akhir-tahun-karut-marut-hilirisasi-nikel-persulit-hidup-masyarakat-lingkungan-makin-sakit.
84 AEER (2024), 'International Women's Day Public Dialogue: "Women in the Nickel Industry"', 15 March 2024, https://www.aeer.or.id/en/the-impact-of-nickel-on-the-lives-of-women-in-the-morowali-nickel-smelter-circle.
85 InvestSA (undated), 'Mining & Mineral Processing', InvestSA, https://www.investsa.gov.za/key-sectors/mining-mineral-processing.
86 Minerals Council South Africa (2024), *Facts and Figures 2023/24: Comprehensive Economic and Operating Data for the South African Mining Industry*, Johannesburg: Minerals Council South Africa, May 2024, https://www.mineralscouncil.org.za/all-categories?task=download.send&id=2533:comprehensive-fact-and-figures-2024&catid=18.
87 USGS (2024), *Minerals Commodity Summaries 2024*, https://pubs.usgs.gov/periodicals/mcs2024/mcs2024.pdf.
88 Minerals Council South Africa (2024), *Facts and Figures 2023/24: Comprehensive Economic and Operating Data for the South African Mining Industry*, Johannesburg: Minerals Council South Africa, May 2024, https://www.mineralscouncil.org.za/all-categories?task=download.send&id=2533:comprehensive-fact-and-figures-2024&catid=18.

of manganese ore and concentrate, over 90 per cent of which went to Asia and just over 5 per cent to Europe.[89] South African manganese ore is exported to India, Japan, South Korea and, most notably, China, for processing and is then exported to parts of Europe (Figure 6).[90]

Figure 6. Destinations of South Africa's manganese production, 2024.



Source: United Nations Comtrade (undated), 'TradeFlow', https://comtradeplus.un.org/TradeFlow (accessed 22 May 2026).

In its 2025 critical minerals strategy,[91] the South African government identified manganese as one of the country's five 'highly critical minerals'.[92] Manganese is used in the production of steel, which accounts for 90 per cent of total global manganese consumption, and is also used in battery cathodes for EVs and energy storage.[93] The versatility of manganese and its application in high-demand sectors, specifically construction and energy-transition technologies, points to likely increased demand. However, at present, manganese is mined in one of the most impoverished and economically underdeveloped parts of South Africa, and its economic benefits are largely realized outside of the country.

Manganese mining takes place predominately in the Kalahari Basin of the Northern Cape where most of South Africa's reserves are found.[94] The region experiences water scarcity, and the local population has inadequate water access. Mining operations in the Northern Cape province have been found to contaminate water

89 Minerals Council South Africa (2024), *Facts and Figures 2023/24: Comprehensive Economic and Operating Data for the South African Mining Industry*, Johannesburg: Minerals Council South Africa, May 2024, https://www.mineralscouncil.org.za/all-categories?task=download.send&id=2533:comprehensive-fact-and-figures-2024&catid=18.
90 González, A. et al. (2021), *Manganese Matters: A Metal of Consequence for Women and Communities in South Africa Affected by Mining and the Global Energy Transition*, Amsterdam: SOMO and Action Aid, https://www.somo.nl/manganese-matters.
91 Department of Mineral and Petroleum Resources (2025), *Critical Minerals and Metals Strategy: South Africa*, Department of Mineral and Petroleum Resources, https://www.gov.za/sites/default/files/gcis_document/202505/critical-minerals-and-metals-strategy-south-africa-2025.pdf.
92 Christianson, D. (2025), 'South Africa joins the critical minerals show', Trade Law Centre, tralacBlog, 18 June 2025, https://www.tralac.org/blog/article/16796-south-africa-joins-the-critical-minerals-show.html.
93 González et al. (2021), *Manganese Matters: A metal of consequence for women and communities in South Africa affected by mining and the global energy transition*.
94 Prager, J. (2024), 'South Africa has one of the world's largest manganese reserves. So why does it outsource for processing?', CNN World, 30 April 2024, https://edition.cnn.com/2024/04/30/africa/manganese-south-africa-exports-electric-vehicles-batteries-spc-intl; African Green Minerals (undated), 'Manganese', *African Green Minerals*.

resources, reducing the quality of already limited water used for drinking and sanitation.[95] Water demand from the mining and agricultural industries is frequently in conflict with communities for whom access to water is a legal right. This has led to a high level of politicization over the control and management of water, which is spread between national and provincial authority levels, often compounding the problems of water governance. These challenges exacerbate long-standing grievances against the mining sector around the process of gaining mineral rights, labour conditions and workers' rights, and illegal mining.

Manganese is mined in one of the most impoverished and economically underdeveloped parts of South Africa, and its economic benefits are largely realized outside of the country.

Communities in the arid and semi-arid Kalahari Manganese Fields, specifically in Maipeng, Magojaneng and Vergenoeg,[96] experience water quantity and quality issues. Field research conducted by the Centre for Research on Multinational Corporations (SOMO) and Action Aid found that these communities are deprived of their access to water and must contend with a reduced water supply, part of which is diverted to mining operations.[97] Studies have found that 'dewatering'[98] can compromise groundwater levels decades after mining activities have concluded.[99] Chemicals have leached into underground water supplies and seepage from tailings dams has contaminated aquifers.[100]

As currently managed, South Africa's water resources are highly vulnerable to the impacts of climate change, over-abstraction and water pollution from urbanization, agriculture and industry. South Africa's legislative measures to introduce integrated water resource management principles[101] include specific requirements for water as part of the overall licence to mine. These principles affect the country's water-pricing approach, which covers water pollution charges, the prioritization of non-mining water users and specific water and mining components.[102]

However, detailed data-driven assessments of the impacts of mining on water resources are not possible due to a lack of capacity. As a result, the Department of Mineral and Petroleum Resources will often license mining operations without

95 González et al. (2021), *Manganese Matters: A Metal of Consequence for Women and Communities in South Africa Affected by Mining and the Global Energy Transition*.
96 Ibid.
97 Ibid.
98 Dewatering is the process of removing or controlling excess water in mines resulting from natural groundwater seepage, surface water run-off or precipitation, all of which can hinder the productivity and safety of mining operations.
99 González et al. (2021), *Manganese Matters: A Metal of Consequence for Women and Communities in South Africa Affected by Mining and the Global Energy Transition*.
100 Ibid.
101 Integrated water resource management is a systemic and sustainable approach to water resources management that takes into consideration the limited nature of water resources and the effects of negative impacts on this resource. See Stockholm International Water Institute (SIWI) (2020), *Principles and Practices of Integrated Water Resources Management Workplace-based Professional Training*, https://siwi.org/wp-content/uploads/2020/06/IWRM_Manual1_final.pdf.
102 Ranchod et al. (2015), 'Assessing the blue-water footprint of an opencast platinum mine in South Africa'.

accurate data on water resources in the region. In SOMO's findings, 62 per cent of surveyed community members expressed concern about water quality, while another 57 per cent said they had no access to water or had to travel long distances to source water, a task that is largely the responsibility of women and girls.[103] Residents are often left to rely on the taste, smell and appearance of their water to determine if it is safe.

Contaminated water in the Kalahari Manganese Field has resulted in health issues for nearby residents, including respiratory, cardiovascular and, for women and girls, reproductive health issues.[104] In addition to these health and safety issues, communities near mines often report not having access to water-based sanitation facilities.[105]

The global market for manganese is expected to reach nearly 40 million tonnes by 2030, and demand is likely to outpace supply, in part driven by the increased demand for steel and the growing application of manganese as a material substitute for other metals like cobalt.[106] Given the unsustainable nature of current manganese sources and rising demand, consumer countries may need to diversify their suppliers of manganese to avoid disruption, while following more sustainable practices. According to 2023 United States Geological Survey data, Australia, Brazil, Gabon and China are also significant producers of manganese.[107]

Chilean copper and lithium

Chile is the world's leading copper producer, holding about 19 per cent of global reserves, and the second-largest producer of lithium, with roughly 33 per cent of known deposits[108] and around 23 per cent of global production.[109] Mining already contributes about 12 per cent to Chile's GDP (2023) and accounts for 57 per cent of the nation's total exports.[110] The main destinations for Chile's mineral resources are China, Japan and South Korea (Figure 7), with new copper demand emerging in India and Vietnam.[111] Demand for copper is driven by battery deployment in EVs and storage, along with construction and grid electrification. Similarly, lithium demand comes from the EV sector as well as battery storage.[112]

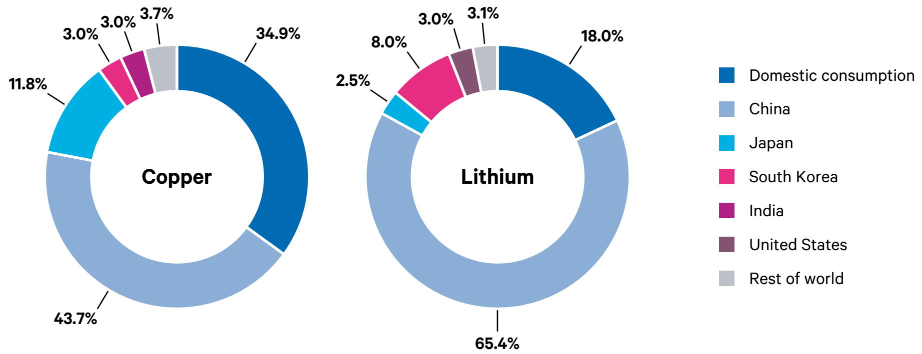
Buoyed by historically strong copper prices and unrelenting demand for lithium in high-tech and battery applications, Chile's mining sector is set to expand. Thirteen key copper projects are moving forward in 2026, seven of which aim

103 González et al. (2021), *Manganese Matters: A Metal of Consequence for Women and Communities in South Africa Affected by Mining and the Global Energy Transition*.
104 Ibid.
105 Ibid.
106 Sokolova, I. et al. (2025), 'From abundant resource to critical commodity: Forecasting manganese supply and assessing its sustainability', *Sustainable Materials and Technologies*, 44, e01349, https://www.sciencedirect.com/science/article/pii/S2214993725001174.
107 Ibid.
108 USGS (2024), *Minerals Commodity Summaries 2024*.
109 Ibid.
110 International Trade Administration (undated), 'Chile Country Commercial Guide: Mining', https://www.trade.gov/country-commercial-guides/chile-mining.
111 IEA (2025), *Global Critical Minerals Outlook 2025*, Paris: IEA, https://iea.blob.core.windows.net/assets/ef5e9b70-3374-4caa-ba9d-19c72253bfc4/GlobalCriticalMineralsOutlook2025.pdf.
112 Ibid.

to start operations and the other six will begin construction.[113] The industry's requirement for skilled workers is set to grow by more than 34,000 by 2032.[114] Investment plans also reflect this momentum: between 2024 and 2033, companies are evaluating 51 projects worth a combined $83 billion, a 25 per cent increase from the 2023–2032 portfolio.[115]

Chile also has copper refining facilities and aims to develop its midstream manufacturing capacity for cathodes and recycling technologies.[116] Increased onshoring of manufacturing or processing before export might reap higher economic benefits for Chile per litre of water consumed and polluted, but will also put more overall pressure on local water resources.

Figure 7. Destinations of Chile's copper and lithium production, 2024



Source: United Nations Comtrade (undated), 'TradeFlow', https://comtradeplus.un.org/TradeFlow (accessed 22 May 2026); Belder, D. (2025), 'Top 10 Copper Producers by Country', Nasdaq, 25 February 2025, https://www.nasdaq.com/articles/top-10-copper-producers-country; Reuters (2025), 'Chile's mining agency expects another global lithium surplus this year', Mining.com, 23 January 2025, https://www.mining.com/web/chiles-mining-agency-expects-another-global-lithium-surplus-this-year.

Chile's mineral wealth makes it a vital trading partner in the global economy. The country is grappling with intense water scarcity, due to both an increase in water consumption, which doubled from 1960 to 2024, as well as a general decrease in surface water availability, due to lower rainfall and the effects of climate change.[117] Mining water withdrawals make up 4 per cent of all water use in Chile.[118] In the country's arid mining regions, water withdrawals can

113 Jamasmie, C. (2025), 'Chile loads its copper cannon with 13 projects for a bullish 2026', Mining.com, 23 December 2025, https://www.mining.com/chile-fast-tracks-13-copper-projects-in-bullish-2026-market.
114 Global Business Reports (2024), 'The Chilean Mining Renaissance', https://www.gbreports.com/article/the-chilean-mining-renaissance.
115 International Trade Administration (2023), 'Chile Country Commercial Guide: Mining'; InvestChile (undated), 'Mining', https://www.investchile.gob.cl/key-industries/mining; Cochilco (2023), 'Inversión en la Minería Chilena: Cartera de proyectos 2024-2033' [Investment in Chilean Mining: Project Portfolio 2024-2033], Santiago: Comisión Chilena del Cobre, https://www.cochilco.cl/web/inversion-en-la-mineria-chilena-cartera-de-proyectos-2024-2033.
116 Netherlands Commission for Environmental Assessment (NCEA) (2025), *Mineral Resource Governance in the Global Energy Transition – A qualitative survey of views from minerals-rich countries*, Utrecht: Netherlands Commission for Environmental Assessment, https://www.eia.nl/en/wp-content/uploads/2025/06/SusAn2-Final-Version-June-2025.pdf.
117 Center for Climate and Resilience Research (2024), 'Water Crisis in Chile: Are We Close to the Zero?', 30 April 2024, https://www.cr2.cl/eng/water-crisis-in-chile-are-we-close-to-day-zero.
118 González, J. D. V. (2024), 'Desalination in Chile: A crucial challenge for sustainable development and the importance of mining in the industry', Dentons Mining Law Blog, 22 January 2024, https://www.dentonsmininglaw.com/desalination-in-chile-a-crucial-challenge-for-sustainable-development-and-the-importance-of-mining-in-the-industry.

be of significant consequence for the environment.[119] The development of the agricultural and forestry sectors, which represent about 72 per cent of freshwater consumption,[120] has intensified the demand for water.

In response, Chile has invested heavily in desalination plants to minimize freshwater use, particularly for the mining sector. In 2024, Chile had developed 24 desalination plants, which have the capacity to produce 8,500 litres of fresh water per second.[121] Desalination of seawater currently accounts for 30 per cent of the mining industry's water consumption and is expected to reach 50 per cent by 2030.[122] Seventy-five per cent of desalination operations are funded by mining companies active in Chile, which have developed public–private partnerships with companies specializing in water desalination.[123] This technology can reduce pressure on freshwater resources but that benefit is modulated by the water consumed and polluted through energy production for the processing and transport of water.

Based on this approach, seawater desalination can affect the water footprint of mining. This depends on how much fresh water is consumed and/or produced in the desalination process, the energy required for transporting the water to the location of use and the treatment of brine waste.[124] Water desalination is not yet a sustainable long-term solution and has its drawbacks, namely it produces highly saline wastewater that, when returned to the sea, negatively affects marine ecosystems. The high cost and technical difficulty of transporting treated water remain a challenge. Furthermore, studies have found that desalination has not replaced the mining sector's use of fresh water but merely supplemented it.[125]

The rapid expansion of mining projects in Chile has been met with growing resistance from local community members concerned about the environmental impacts. An August 2023 report indicated that out of 120 active mineral mine projects in Argentina and Chile, over 50 per cent are in conflict with local communities.[126] Globally, around 54 per cent of critical minerals are located on or near Indigenous peoples' land,[127] which has caused tension between the Indigenous communities and mining companies that want to exploit mineral resources.

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119 FAO (undated), 'AQUASTAT Core Database', Food and Agriculture Organization of the United Nations, https://data.apps.fao.org/aquastat/?lang=en.
120 González (2024), 'Desalination in Chile: A crucial challenge for sustainable development and the importance of mining in the industry'.
121 Ibid.
122 Almar Water Solutions (2023), 'Water, an essential resource for mining in Chile', 13 July 2023, https://almarwater.com/water-an-essential-resource-for-mining-in-chile/#:~:text=In%20terms%20of%20technologies%2C%20desalination,seven%20more%20in%20the%20pipeline.
123 González (2024), 'Desalination in Chile: A crucial challenge for sustainable development and the importance of mining in the industry'.
124 Zhang, X. et al. (2022), 'Estimation of water footprint in seawater desalination with reverse osmosis process', *Environmental Research*, 204, https://doi.org/10.1016/j.envres.2021.112374.
125 Fitzsimons, E. and Warren, P. (2024), 'Desalination investment for copper mining: Barriers and opportunities in Chile', *The Extractive Industries and Society*, 17, 101449, https://www.sciencedirect.com/science/article/pii/S2214790X24000479.
126 Institute of Development Studies (IDS) (2023), 'Scale of conflict between mineral mines and indigenous peoples revealed', 9 August 2023, https://www.ids.ac.uk/news/scale-of-conflict-between-mineral-mines-and-indigenous-peoples-revealed.
127 IRENA (2023), *Geopolitics of the Energy Transition: Critical Materials*, Abu Dhabi: International Renewable Energy Agency, https://www.irena.org/Digital-Report/Geopolitics-of-the-Energy-Transition-Critical-Materials.

In Chile's Atacama Region, Indigenous groups have expressed concern that mining depletes their water supplies, which are already under stress from the lack of rainfall. Mining operations in the region consume water at a rate that dwarfs domestic use, depleting water available for Indigenous Lickanantay communities, impacting agriculture and traditional livelihoods.[128] Indigenous community members have exercised their rights, through government legislation, to engage in talks with two of Chile's largest mining companies. The local community wants to have more influence over lithium extraction plans, specifically to limit water use and to ensure corporate accountability for environmental pledges.[129]

In 2005, legal reform of the Water Code stipulated that, when granting new water rights, the government must ensure that the rights holder, from industries like mining and agriculture, leaves a minimum amount of water in a river (a minimum ecological flow). This amount is capped at just 20 per cent of a river's average annual flow but in some cases authorities implemented a stricter cap of 40 per cent. In many instances, this limit is insufficient to meet basic environmental requirements, does not reflect seasonal variations in ecological water needs and fails to adapt protected flows in relation to climate change.[130] The law was not applied retroactively. As a result, by the time it came into force, water rights for many rivers in northern and central Chile were already allocated and, in some cases, over-allocated leaving little left to protect.

Even though desalinated water is supporting the mining industry in Chile, it does not solve the issue of water scarcity for other sectors, like agriculture, and domestic users. Regulatory uncertainty and limited public acceptance of water desalination (in addition to water scarce conditions) are potential threats that could have consequences for the mining sector's ability to deliver materials for the growing global market. Chile's existing trade dependencies will become further strained in the future by issues related to water availability and demand for copper and lithium outpacing the country's production capacity. Insufficient minerals supply, at least in the short term, will be of consequence for lithium-dependent sectors.

128 González, A. (2025), 'Why Chile's mines are turning to the sea', Mining Technology, 29 May 2025, https://www.mining-technology.com/features/why-chiles-mines-are-turning-to-the-sea/?cf-view&cf-closed.
129 Institute of Development Studies (2023), 'Scale of conflict between mineral mines and indigenous peoples revealed'.
130 Salazar, P. W., Macpherson, E. and Willaarts, B. A. (2024), 'Towards durable legal protections for rivers in Chile', *Water International*, 49(6), pp. 792–815, https://doi.org/10.1080/02508060.2024.2346394. https://pure.iiasa.ac.at/id/eprint/19868/1/Towards%20durable%20legal%20protections%20for%20rivers%20in%20Chile.pdf.

05
Trends in the mining sector

Voluntary and mandatory regulatory measures that can address governance fragmentation and increase transparency are necessary for secure global supplies of minerals.

In the race for global resources, recent trends have emerged that will impact future supply, demand and extraction of critical minerals, as well as where new or expanded mining and processing activity takes place. What might that mean for water use and water risks?

The West turning inward

Mineral supply chains are complex and, as described in this paper, can both drive and be vulnerable to water insecurity that transcends borders. The current geopolitical and trade environment is increasingly fractured, making shared global water security a greater challenge. Meanwhile, the issue goes unseen and is rarely discussed in political chambers or negotiating halls. New political imperatives for energy independence, economic competitiveness and supply-chain security are propelling efforts to increase self-sufficiency and protectionism, as well as eroding the space and political will for collaborative global governance. In the case of energy independence, even if achieved through clean energy sources, it is still contingent on infrastructure with increasing critical minerals requirements.

Nonetheless, as minerals needed for the green energy transition are increasingly central to the global economy, dependence on these vital resources will accelerate, expanding global supply chains of minerals and end-use technologies. Consideration of the virtual water embedded in these products is a key factor in protecting neighbouring communities, biodiversity and ensuring stable supplies. Addressing the risks that come with the production of critical minerals, particularly to water and by extension climate resilience and community livelihoods, necessitates collaboration between producer- and consumer-country governments, mining companies, the local population, investors, manufacturers and retailers. However, as countries prioritize national interests, looser policies and regulations are being adopted that hinder rather than support shared water security in critical mineral supply chains.

One manifestation of these dynamics is that more mining and processing activities are expected to take place to supply Europe. In 2025, under the Critical Raw Materials Act (CRMA), the European Commission stated that it will build up domestic supply of critical raw materials through 60 strategic investments.[131] Forty-seven of these projects are in EU member states and 13 are outside the bloc (with projects located in Canada, Greenland, Kazakhstan, Norway, Serbia, Ukraine, Zambia, Brazil, Madagascar, Malawi, New Caledonia, South Africa and the UK).[132] According to analysis from Watershed Investigations, referenced by the *Guardian*, half of the announced strategic projects are located in areas that have experienced increasing drought conditions in 2026 and a quarter of the projects are in highly water-stressed areas in Spain, Portugal and Greece.[133] These strategic initiatives will receive fast-tracked and streamlined permits and financing.[134] The processing period for minerals production permits now cannot exceed 27 months for extractive projects and 15 months for processing or recycling projects.[135] The ReSourceEU Action Plan, announced in December 2025, sets the operational framework for the CRMA. The plan aims to mobilize €3 billion by the end of 2026 and increase mineral extraction for key industries like clean technology and defence.[136]

The EU's simplified and more streamlined process for new mining projects reflects an evolving set of priorities for the European Commission: supply-chain security. The omnibus package, announced in February 2025, aimed to simplify sustainability reporting requirements for large companies, specifically the Corporate Sustainability Due Diligence Directive (CSDDD), the Corporate Sustainability Reporting Directive (CSRD) and, more recently, the Water Framework Directive. The introduction of these changes has been critiqued by legal experts for weakening due diligence standards for mineral supply chains and limiting stakeholder engagement in producing regions.[137]

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131 Campbell, R., Ahmad, K. and Forwood, G. (2025), 'Strategic Projects for the EU: list of 47 Strategic Projects announced', White & Case, 2 April 2025, https://www.whitecase.com/insight-alert/strategic-projects-eu-list-47-strategic-projects-announced; European Commission (2025), 'Commission selects 13 Strategic Projects in third countries to secure access to raw materials and to support local value creation', 4 June 2025, press release, https://ec.europa.eu/commission/presscorner/detail/en/ip_25_1419.
132 Fabian, E. (2025), 'Commission selects 47 strategic projects to secure access to raw materials', CEEENERGYNEWS, 25 March 2025, https://ceenergynews.com/renewables/commission-selects-47-strategic-projects-to-secure-access-to-raw-materials.
133 Salvidge, R. (2026), '"It's Russian roulette": alarm as Europe backs critical minerals mines in water-stressed regions', Guardian, 20 June 2026, https://www.theguardian.com/environment/2026/jun/20/europe-backs-critical-minerals-mines-water-stressed-regions.
134 Campbell, Ahmad and Forwood (2025), 'Strategic Projects for the EU: list of 47 Strategic Projects announced'.
135 Marin, D., Pravuljac, M., Tramalka, I. and Martins, M. (2024), *Understanding Strategic Projects Under the CRMA: A Guide to Rights and Processes*, ClientEarth, https://eeb.org/wp-content/uploads/2024/12/Digital-Community-Guidelines-for-Strategic-Projects.pdf.
136 European Commission (2025), *RESourceEU Action Plan: Accelerating the EU's raw materials strategy and supply chain diversification*, Brussels: Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, 2025, https://single-market-economy.ec.europa.eu/document/download/e9ac2181-0dc7-4e61-a964-ba0a39c2aea8_en.
137 The Good Lobby (2025), 'Over 100 legal experts warn Omnibus I risks breaching EU law', 10 November 2025, https://thegoodlobby.eu/over-100-legal-experts-warn-omnibus-i-risks-breaching-eu-law.

Weakened European environmental standards coupled with the regulatory gaps in some producer countries pose threats to environmental sustainability and the protection of human rights.

Similarly, the US is seeking to restore its 'mineral dominance' and has framed its ambitions through the logic of energy security. In 2025, the US administration engaged Ukraine in negotiations for a minerals security partnership and issued a series of executive orders to increase domestic production and fast-track deregulation. To establish the US as a leading producer and processor of non-fuel metals, the Trump administration is prioritizing job creation, 'fuel prosperity',[138] defence capabilities and reduced reliance on the mineral production of 'hostile foreign powers'.[139]

Increasing overall production of minerals with large water footprints in water scarce regions is risky for mineral supply, social justice and environmental sustainability.

The US is simultaneously committed to lowering the barriers to entry for new mining actors and increasing the investment of existing ones, through weakened due diligence for the financing of mining projects and a pause on anti-bribery protections, which comes from a February 2025 executive order that paused the Foreign Corrupt Practices Act (FCPA). Executive Order 14154 instructed the Council on Environmental Quality to rescind all National Environmental Policy Act (NEPA) regulations (rescission of NEPA regulations, as of January 2026, has officially been finalized);[140] federal agencies have been ordered to revise their NEPA regulations as well as prioritize permit issuance speed and the removal of obstacles. The One Big Beautiful Bill Act also aims to accelerate domestic sourcing of minerals, for example, with the development of the Hell's Kitchen lithium mine in California. Set to be one of the largest lithium mines in the world, the project is in one of California's most water scarce and polluted areas, and it is already experiencing resistance from local environmental groups and Indigenous communities.[141]

These changes to US policy severely weaken environmental laws by limiting public participation, transparency and accountability.[142] As such, water use by the mining sector will likely be opaque, making monitoring and evaluation of water resource quality and quantity even more challenging.

138 The White House (2025), 'Executive Order on Immediate Measures to Increase American Mineral Production', 20 March 2025, https://www.whitehouse.gov/presidential-actions/2025/03/immediate-measures-to-increase-american-mineral-production.
139 Ibid.
140 The White House (2025), 'Executive Order 14154: Unleashing American Energy', 20 January 2025, https://public-inspection.federalregister.gov/2025-01956.pdf.
141 Riedl, D., Saha, D. and Balleny, L. (2026), 'A New Era of US Mineral Mining Must Put Communities First', WRI Commentary, https://www.wri.org/insights/us-critical-mineral-mining-community-impacts.
142 Bense, K. and Myskow, W. (2025), 'Trump Administration Acts to "Severely Weaken" a Key Environmental Law', Inside Climate News, 2 July 2025, https://insideclimatenews.org/news/02072025/trump-administration-weakens-national-environmental-policy-act.

In both cases, mining and processing industries in the EU and US would likely only add to global production rather than replace minerals production elsewhere. Increasing overall production of minerals with large water footprints in water scarce regions is risky for mineral supply, social justice and environmental sustainability. Demand reduction measures are largely absent from the CRMA, the ReSourceEU Action Plan and US executive orders. These observed trends in the policy and regulatory environment detract from much-needed commitments to the equitable, sustainable and efficient use of water in the mining sector – not only to protect communities and the environment but also to ensure stable supplies of these minerals. Without the commitment and collaboration of all stakeholders in the mineral supply chain, local communities will bear the brunt of water and livelihood risks due to unsustainable water use. Under such circumstances, it will not be long before the financial, reputational and economic risks are felt by companies, investors and consumers as well.

Moving towards sustainability

Sustainable mineral supply chains require balancing the urgent demand for minerals with the imperative to protect the environment and human rights. Public oversight tools such as multilateral environmental agreements, customary international law, human rights instruments, international trade and investment treaties, and non-binding policies, e.g. the UN Sustainable Development Goals, all contribute to the governance of the mining and minerals sector. Additional regulatory measures that are not specific to mining can improve the social, environmental and economic sustainability of extractive activities. These include strategic environmental assessments, environmental and social impact assessments, and pollutant release and transfer registers. In the EU, the Water Framework Directive, EU Extractive Waste Directive, Corporate Sustainability Due Diligence Directive and the EU Battery Regulation provide further examples of mandatory legal instruments for the sourcing of minerals and mining impacts.

The expansion of mining activities has been matched by the proliferation of sustainability standards and initiatives (SSIs) under various authorities promoting responsible practices and sustainability commitments, with more than 100 SSIs operating across minerals and metals supply chains. These SSIs can have a geographical scope from the international level to the mining site; address individual or groups of minerals; be focused on responsible production, sourcing or consumption; and include artisanal, small-, medium- and large-scale miners.[143]

This diversity of SSIs creates a complex landscape of overlapping standards that can be a barrier for their uptake and implementation. Recognizing the limitations of multiple and disparate SSIs, the International Council on Mining and Minerals (ICMM), the Copper Mark, the Mining Association of Canada and the World Gold

143 UNEP (2025), *Stocktake of Sustainability Standards and Initiatives for Minerals and Metals: Leveraging Synergies Between Sustainability Standards and Initiatives and Public Instruments to Enhance Environmental Governance*, https://wedocs.unep.org/20.500.11822/48989.

Council are working together to create a consolidated mining standard that will clarify responsible practices for mining companies of all sizes, across all locations and commodities.[144]

Faced with almost an inevitable increase in mining for the minerals critical to technology, SSIs offer perhaps the most practical steps for improving water-use practices and reducing pollution (Table 2). However, the priorities of these vary. As an illustration, a review of 15 SSIs showed that most targeted social issues, followed by the environment, and water was only addressed in five schemes.[145] The use of voluntary standards can and should be leveraged to drive sustainability improvements in mining-related activities. While ideally, such standards function in a complementary way to public governance instruments, in some cases they weaken and even conflict with public oversight by confusing the rules and leading to delay or displacement of regulatory reforms and enforcement.[146]

Guidance, principles and disclosure mechanisms complement mandatory and voluntary measures. The OECD *Due Diligence Guidance for Responsible Mineral Supply Chains* supports assessment of risks associated with sourcing of minerals.[147] The UN Secretary-General's Initiative on Critical Energy Transition Minerals has produced seven guiding principles and actionable recommendations that focus on human rights, the integrity of the planet, and justice and equity in mineral supply chains.[148] Meanwhile, CDP's annual questionnaire addresses water security through questions about a company's water usage, management of water-related risks and opportunities, water withdrawal and discharge, and impact across its supply chain. The CDP Water Watch Tool ranks over 200 industrial activities within 13 industry sectors including mining and minerals processing. In 2026, the tool categorized the water quantity and quality impacts of metallic minerals mining, smelting, refining and forming as 'critical'.[149] In another example, Global Reporting Initiative (GRI) is the most widely used sustainability reporting system and has standards for reporting on water (GRI 303), waste (GRI 306) and mining (GRI 14).[150] Together, public governance instruments, SSIs, guidance, principles and disclosure should be leveraged to drive sustainability improvements in mining-related activities.

144 Mining Standard Initiative (undated), 'Consolidated Mining Standard Initiative', https://miningstandardinitiative.org.
145 Mori Jr, R., Franks, D. M. and Ali, S. H. (2015), *Designing Sustainability Certification for Impact: Analysis of the design characteristics of 15 sustainability standards in the mining industry*, Centre for Social Responsibility in Mining, Brisbane: University of Queensland, https://www.csrm.uq.edu.au/media/docs/1202/csrm-report-final.pdf.
146 Ibid.; UNEP (2025), *Stocktake of Sustainability Standards and Initiatives for Minerals and Metals*.
147 OECD (2016), *OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas: Third Edition*, http://dx.doi.org/10.1787/9789264252479-en.
148 United Nations (2024), *Resourcing the Energy Transition: Principles to Guide Critical Energy Transition Minerals toward Equity and Justice*, https://www.un.org/sites/un2.un.org/files/report_sg_panel_on_critical_energy_transition_minerals_11_sept_2024.pdf.
149 CDP (undated), 'CDP Water Watch', https://www.cdp.net/en/disclose/question-bank/water-security/water-watch.
150 Global Reporting Initiative (undated), 'Sector Standard for Mining (GRI 14)', https://www.globalreporting.org/standards/standards-development/sector-standard-for-mining.

Table 2. Mining sector voluntary standards and initiatives

Initiative	Description	Standard	How water risks are addressed
Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF)[151]	Global intergovernmental policy forum on mining with the objective to improve, enhance and promote the contribution of mining, minerals and metals to sustainable development and poverty reduction.	IGF Mining Policy Framework,[152] a compendium of best environmental, social and economic governance practices for governments.	Provides guidance on effective laws, policies and regulations on water quality and quantity management in mine sites and at the river basin level across all mine types.
Extractive Industries Transparency Initiative (EITI)	Promotes understanding of natural resource management, strengthens public and corporate governance and accountability, and provides data to inform policymaking and multi-stakeholder dialogue in the extractive sector.	EITI Standard 2023, a global benchmark for transparency in the oil, gas and mining sectors.	Discloses environmental information, and facilitates social monitoring activities related to water, land, emissions and human rights.
Initiative for Responsible Mining Assurance (IRMA)[153]	Provides an independent assessment of all mined materials for industrial-scale mines.	IRMA Standard for Responsible Mining includes four principles: business integrity, planning and managing positive legacies, social responsibility, and environmental responsibility.[154]	Waste and materials management including wastewater treatment for sludge and tailings, as well as water management of surface water and groundwater at local and regional levels.
International Council on Mining and Metals (ICMM)[155]	Industry body promoting leadership in the contribution of mining and minerals to sustainable development.	Includes 10 mining principles defining requirements for good environmental, social and governance practice in the mining and metals industry.[156]	Principle 6: Environmental Performance includes guidance for mine closure, the implementation of water stewardship practices, effective management of tailings, the prevention of pollution and the management of releases and waste.
The Copper Mark[157]	Leading assurance framework to promote responsible practices across the copper, molybdenum, nickel and zinc value chains.	Copper Mark standards include Risk Readiness Assessment Criteria Guide, Joint Due Diligence Standard for Copper, Lead, Molybdenum, Nickel and Zinc, Copper Mark Chain of Custody Standard.[158]	Criteria 28, 31 and 33 aim to avoid, minimize, rectify, and compensate for adverse impacts on water balance, flow, quality and access, and take into account the needs of other water users and wildlife in operational activities, tailings and pollution.

Source: Compiled by the authors.

151 IGF (undated), 'IGF Mining', https://www.igfmining.org.
152 Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF) (2023), *Mining Policy Framework: Mining and Sustainable Development*, https://www.iisd.org/system/files/2023-12/igf-mining-policy-framework-en.pdf.
153 Responsible Mining Foundation (undated), 'Standards that Dig Deeper & Assurance at Every Level', https://responsiblemining.net.
154 Initiative for Responsible Mining Assurance (2018), *IRMA Standard for Responsible Mining v1.0 EN*, https://responsiblemining.net/wp-content/uploads/2018/07/IRMA-Standard-for-Responsible-Mining-v1.0-EN.pdf.
155 ICMM (undated), 'ICMM in Focus', https://www.icmm.com.
156 ICMM (undated), 'Our Principles', https://www.icmm.com/en-gb/our-principles.
157 The Copper Mark (undated), 'The Copper Mark', https://coppermark.org.
158 The Copper Mark (undated), 'Core Documents', https://coppermark.org/standards/core-documents.

06 Conclusion and recommendations

Addressing the water risks of increased mineral demand will require coordination across the supply chain. While the current geopolitical context makes this more challenging, there are ways for policymakers and companies to boost supply-chain resilience and sustainable mining.

The production of critical minerals – such as cobalt, copper, lithium, nickel, manganese and rare earth elements – is indispensable to the global economy and the energy transition. Yet extractive activities are closely tied to water consumption and pollution, which creates and exacerbates negative social, environmental and economic impacts that are likely to grow as mining production inevitably increases. The monitoring and prevention of these impacts are vital for the stable and sustainable supply of critical minerals.

Ensuring fairness for all parties and the environment, across the supply chain – from producers to consumers and all who are affected by mining and minerals processing, manufacturing, use and final end-of-life disposal – is essential. The following recommendations offer practical approaches to achieve more sustainable mineral supply chains and a fairer water footprint in the mining sector.

Governments should pursue cross-sectoral coordination. Many governments struggle to balance short-term revenue needs with long-term environmental and social safeguards, often due to the lack of political will, institutional capacity, funding and/or insufficient cross-sectoral coordination. Broader engagement on the part of government institutions and supervisory bodies in balancing demands is necessary to boost the level of political will to address some of the larger structural factors preventing a more coordinated approach. This includes ensuring that actions move beyond disparate interventions that are siloed in individual sectors or government departments. Instead, a holistic approach is needed that aims to strengthen coordination between ministries responsible for water, agriculture, energy, industry, the environment, economic development and finance. This coordination can be facilitated through a basin-level assessment that integrates: water availability, sectoral withdrawals, return flows and pollution loads, land-use and hydrological connectivity, governance arrangements, and economic drivers to understand cumulative impacts and trade-offs across the basin. Such an assessment can be undertaken by governments or in partnership with the private sector.

Authorities should reassess the value of water in governance. Basin-level assessments will reveal the true economic, environmental and social costs of water use across competing sectors. Strengthening water governance in producing countries requires integrating these basin-level insights into allocation rules, permit systems and pricing mechanisms, so that exported and domestically traded goods reflect the real value of water. Drought and flood planning in the context of climate change should be integrated into the allocation of permits for mining and minerals processing activities to avoid impacts that could limit production and the availability of water. Further cross-sectoral integration is possible through the coordination of water, climate and biodiversity actions across government agencies and the identification of synergies between producer and consumer countries as well as public and private sector entities.

Private sector actors will benefit by recognizing and addressing water risks. Evidence from across the mining sector shows that water risks are translating directly into financial and operational costs. Mining companies are increasingly forced to invest in expensive alternatives to freshwater resources such as desalination plants, long-distance pipelines and enhanced treatment systems to secure water supplies.

Failures in tailings management have demonstrated how catastrophic accidents can devastate communities and ecosystems while destroying corporate value. Financiers and downstream industries are beginning to recognize that water scarcity, flooding and climate risks are material to their portfolios and supply chains. Water is no longer seen as a peripheral compliance issue but increasingly as a strategic resource that determines competitiveness and viability. Addressing these water risks at all stages of mining and minerals activities will contribute to securing supply chains.

Investors and financiers would benefit by integrating water and climate risks into credit and market models, evaluating portfolios against water stress and extreme weather events, and making climate resilience a condition of capital. To meet potential stricter government regulation, consumer pressure and conditions of finance, mining companies must invest in operational improvements such as closed-loop water systems, aggressive recycling and robust tailings management with independent audits and emergency planning. Investing in recycling and circularity to meet primary demand can contribute to decreasing the pressure on water resources.

Companies and governments should collaborate on inclusive approaches. Assurance of environmental and human rights safeguards requires the meaningful participation of affected communities and civil society. Stronger state leadership, more comprehensive permit requirements – including on climate change, accountability and reporting – and multi-stakeholder platforms that include stakeholders in decision-making are needed to ensure that social and environmental safeguards are embedded in mining governance and operations. It is important for mining and minerals processing companies to demonstrate increased commitment to inclusive consultation and community engagement and a willingness to address local concerns. Benefit-sharing agreements can ensure that economic gains are shared fairly with local communities and Indigenous peoples. The input of civil society and communities is crucial for monitoring impacts, advocating for rights and attempting to hold both companies and governments accountable. Where mining encroaches on Indigenous lands or vulnerable ecosystems, the absence of transparent and participatory decision-making between the various stakeholders undermines trust and legitimacy.

Private and public actors should adopt a whole-of-supply-chain approach. Downstream industries can boost demand for responsibly sourced minerals by mandating social and environmental safeguards and referring to existing sustainability guidelines, such as the OECD's *Due Diligence Guidance for Responsible Mineral Supply Chains*, in procurement and trade agreements. If such agreements are designed to evaluate water use and risks through basin-level assessments and establish means for data disclosure, transparent oversight and resilience planning, they can incentivize trade partners to cooperate on virtual water trade governance. Trade and domestic policies need to reflect the true value of water to prevent the worsening of water scarcity in exporting countries. Accounting for the opportunity costs and associated social and environmental impacts of water use in the production of minerals in water pricing can avoid subsidies and incentives that prevent sustainable, equitable and efficient virtual water trade.

Fair water footprints should be adopted across mineral supply chains. The governance recommendations mentioned above along with the adoption of the fair water footprint principles across the entire supply chain could provide a strong basis for ensuring that the trade in critical minerals meets sustainability criteria. SSIs are one element that can provide clear guidance on what companies should aspire to. The efforts by ICMM, the Copper Mark, the Mining Association of Canada and the World Gold Council to create a consolidated mining standard represents a positive move towards more standardized expectations of best practice.

Care must be taken through transparency and independent audits to avoid greenwashing by companies and through engagement of the public sector in producer countries to avoid usurping government authorities in managing activities in their country. Currently, the environment and water are not well addressed in SSIs. The rising concerns about water reported to CDP by companies and finance institutions should encourage more comprehensive guidance on the sustainability issues associated with water consumption and pollution.

Take collective action across the supply chain. To succeed, sustainable virtual water trade is likely to require a greater degree of collective engagement. Nations seeking to further international cooperation, such as those that signed the Glasgow Declaration for Fair Water Footprints at the COP26 UN climate summit in 2021,[159] should continue to engage and learn from one another in and beyond such forums

159 Fair Water Footprints (2021), 'The Glasgow Declaration for Fair Water Footprints for Climate-Resilient, Inclusive, and Sustainable Development'.

to ensure their trade dependencies – critical minerals included – better support shared water security and drive global ambition forwards. At the basin level, collective action can function under integrated water resources management (IWRM), Water–Energy–Food–Environment Nexus (WEFE Nexus), regional planning processes, and/or through corporate water stewardship.

Producer, intermediary and consumer countries should boost multilateral cooperation. Along the supply chain, as policy shifts to account more fully for environmental and social safeguards, there will need to be a mechanism for trading partners to voice concerns – for example, through diplomatic channels such as the Trade and Environmental Sustainability Structured Discussions (TESSD) at the World Trade Organization (WTO). TESSD aims to identify concrete actions that members can take individually or collectively, including ways to assess whether goods and services that impact biodiversity and natural resources, including textiles, transportation, agriculture, electronics and waste, can contribute to environmental and developmental sustainability.[160]

In December 2026, there is the prospect of furthering the water cause at the 3rd UN Water Conference, which will be co-hosted by the United Arab Emirates and Senegal. The conference presents a rare opportunity for the international community to agree on measures to accelerate implementation of SDG 6 on ensuring the availability and sustainable management of water and sanitation for all.

Critical minerals are the backbone of the clean energy transition, but the sustainability of their trade hinges on how water is managed. By engaging all actors across the supply chain – from mine to market to recycling loop – there is an opportunity to reduce impacts, protect communities and ecosystems, and secure the long-term viability of the green energy transition. Water stewardship, climate resilience and transparent governance are not peripheral concerns but decisive factors that will determine whether the mineral economy contributes to a just and sustainable future.

160 World Trade Organization (2025), 'Members deepen discussions on key sustainability topics and potential MC14 outcomes', 30 October 2025, https://www.wto.org/english/news_e/news25_e/tessd_30oct25_189_e.htm.

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Cover image: Excavators and trucks at a nickel mining operation in Pomalaa in southeast Sulawesi, Indonesia, February 2023.
Photo credit: Copyright © Adek Berry/AFP/Getty Images

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