

Cumulative Climate Risks for Transition Minerals in Brazil

April 2025



Brazil's government hopes to turn the country into a key supplier of transition minerals (TMs)¹ and is well-positioned to do so given rich untapped reserves and strong international interest. Its non-aligned geopolitical status means it could play an essential role in efforts to diversify TM supply chains, reducing concentration risks.

However, mining has already had severe negative impacts on Brazil's rich ecosystems and diverse communities. The adverse effects of climate change further exacerbate the social and environmental risks posed by the industry while increasing the chances of disrupted mineral production.

This report examines the mining sector in four of the most important states for mining in Brazil: Pará, Minas Gerais, Goiás and Bahia. All are also highly exposed to climate and social-grievance risks, underscoring the need for proactive risk management to adapt to climate impacts and strong policy frameworks to ensure standards are upheld as the industry enters a period of rapid expansion.

Contributions

Mining Observatory

Research and text: Maurício Angelo and Gabriela Sarmet

The Mining Observatory is an investigative journalism center and think tank focused on the extractive sector, created in 2015. It specializes in covering the role of mining in the climate crisis and energy transition, the role of multinational companies, and the socio-environmental impacts of mining and prospecting.

TMP

TMP is a consulting group dedicated to understanding and solving complex climate, environmental, social, and security problems. This report incorporates climate and social risk analyses conducted by TMP, providing data-based insights into four key mining states. TMP's contribution focuses on assessing climate and social risks to support an understanding of cumulative climate challenges in these regions.

Financial collaborators of the Mining Observatory:

Instituto Clima e Sociedade and Fundação Heinrich Böll - Brazil

1 Materials that are key for energy transition technologies, like renewable energy, electric vehicles (EVs), and electricity grids. These include lithium, copper, rare earth elements (REEs), graphite, cobalt, nickel and manganese.

Supporters



Data provided by



EXECUTIVE SUMMARY

- Managing the adverse impacts of mining in the context of rapid climate change will require a proactive approach to risk management from companies, strong policy frameworks to ensure effective incentives, robust oversight by authorities, and better mechanisms to involve rights-holders in key decisions.
- Strict health and safety standards, thorough consultations with local communities, and comprehensive reparations for those adversely affected are essential measures. Free, prior and informed consent (FPIC) should also be a key pillar of decision-making.
- Pará, Minas Gerais, Goiás and Bahia are all exposed to considerable shifts in climate patterns in the near-term (up to 2030). Specifically, we expect radical changes in temperature and precipitation, both in their extremes and seasonality.
- Erratic precipitation raises the risk of floods, which can cause tailings pools to contaminate the surrounding environment. It can also lead to longer dry periods, increasing drought risk and pressure on water resources. Extreme heat meanwhile can disrupt operations to protect workers' safety.
- Without effective adaptation efforts, climate impacts will exacerbate existing social grievances and disputes between stakeholders, potentially fueling disputes and violent conflict.
- Pará is the most-exposed of the four states to the majority of climate risks we assessed, making it a fitting host for COP30 in 2025. It also has the highest exposure to grievance risk—a number of major miners in the state are embroiled in disputes with local communities, including Vale S.A. (Brazil), MRN/Glencore (Brazil/Switzerland) and Norsk Hydro (Norway).
- Minas Gerais is highly exposed to an increased risk of drought. This is especially concerning given Brazil's high reliance on hydro power. The state currently accounts for the majority of national lithium production.
- Goiás and Bahia also face high exposure to consecutive dry days and extreme temperatures, suggesting that water scarcity is a growing risk factor. Goiás is a leading producer of nickel and home to one of Brazil's largest rare earth projects. However, the expansion of TM mining threatens further destruction of the Cerrado biome, which plays a vital role in Brazil's water cycle.

INTRODUCTION

We are seeing a rapid increase in the frequency and severity of extreme weather events² such as heat waves, wildfires, intense rainfall and flooding—as seen in Rio Grande do Sul in 2024.³ Yet, key decision-makers still appear unprepared for the radical climate changes that seem increasingly inevitable in the coming years, regardless of ongoing efforts to curb emissions.⁴

While the Paris Agreement aimed to limit global average temperature increases to 1.5-2.0°C, record-high temperatures in 2023⁵ and 2024⁶ coupled with persistently elevated emissions⁷ highlight the monumental effort still required to decarbonize and achieve these targets.

■ Energy Transition Boosts Mineral Demand

With the goals of the Paris Agreement looking increasingly ambitious, the transition to clean energy and sustainable transportation has never been more critical. It is now widely recognized that mineral supply chains for transition technologies—such as renewable power, electric vehicles, and grid infrastructure—must expand rapidly.

Consequently, demand for critical minerals such as copper, aluminum, and manganese is rising fast and expected to continue increasing. In 2023, lithium demand surged by 30%, while demand for nickel, cobalt, graphite, and rare earth elements (REEs) grew between 8% and 15%.⁸ Given its rich mineral reserves and proximity to the North American market, Brazil and other Latin American countries have a significant role to play in addressing this global challenge.

Paradoxically, decision-makers often overlook the risks that extreme weather events and other climate-related phenomena pose to these TM supply chains. Climate-related challenges, such as droughts and flood-related tailings dam failures, are already impacting TM extraction and processing. Moreover, climate change is exacerbating existing challenges for the sector, including managing socio-environmental impacts. High social and environmental standards are therefore not only vital for communities and ecosystems, but also for enhancing supply chain resilience.

Managing these risks will require substantial up-front investment but could bring significant economic benefits in the long-run while radically improving the local impact of mineral supply chains. In our view, concerted action must urgently be taken to prepare for these upcoming global climate challenges.

This report combines on-the-ground insights from leading local NGO, The Mining Observatory (TMO), with cutting-edge climate and social data and analytical expertise from sustainability consultancy, TMP. We aim to improve understanding of shared risks, while empowering urgent and scalable actions, helping governments, companies and communities best allocate the substantial resources required to tackle the global climate challenge.

2 We define extreme weather events as unusual weather conditions triggered by significant changes in one or more climate indicators (including changes in temperature and precipitation)

3 <https://disasterphilanthropy.org/disasters/2024-rio-grande-do-sul-brazil-floods/>

4 <https://www.ipcc.ch/report/ar6/syr/summary-for-policymakers/>

5 <https://climate.copernicus.eu/copernicus-2023-hottest-year-record>

6 <https://wmo.int/news/media-centre/2024-track-be-hottest-year-record-warming-temporarily-hits-15degc>

7 <https://wmo.int/news/media-centre/greenhouse-gas-concentrations-surge-again-new-record-2023>

8 <https://www.iea.org/reports/global-critical-minerals-outlook-2024/executive-summary>

■ Background: Transition Minerals and Mining in Brazil

A proactive approach to climate risk is particularly important for Brazil as the government is supporting investment in its abundant TM resources, with the hope of turning the country into a key supplier amid growing global demand.⁹ It is strategically well-positioned to do so and leverage efforts to diversify global mineral supply chains, given its non-aligned geopolitical status and relatively stable diplomatic relations with the US and China.¹⁰

Brazil is already a key supplier to the global commodities market, mining ~1.7b tons of minerals annually.¹¹ The country has rich reserves of iron ore, aluminum, tin and gold, as well as various TMs which are set to continue fueling rapid growth of the mining sector.

The country is the second-largest iron ore producer globally, behind Australia. What's more, global supply chains for numerous TMs are heavily concentrated in Brazil, particularly for niobium—the country produces more than 90% of the world's supply, with ~88% coming from just two mines, in Minas Gerais (owned by Brazil's CBMM) and Goiás (owned by China Molybdenum).¹²

Brazil also has the second-largest reserves of graphite and rare earth elements (REEs) globally, the third-largest reserves of nickel, and is the fourth-largest bauxite producer.¹³ And it is among the six largest producers of lithium—with four lithium projects in operation and seven more planned, national output of the metal is projected to increase five-fold by 2028.¹⁴

However, mining has already severely impacted Brazil's rich ecosystems and diverse traditional communities. The push to develop TM reserves raises numerous underappreciated risks that merit urgent attention. Besides threatening mining operations themselves, climate-related risks could exacerbate pre-existing challenges for the industry and local communities, such as water-related risks, social grievances, and resource competition.

The development of TM resources marks a new chapter in Brazil's long history of socio-environmental impacts from mining. The country witnessed one of the worst mining dam disasters ever in 2019: the collapse of Vale S.A.'s Brumadinho dam in Minas Gerais, which killed 270 people. Mining output has continued to ramp up despite the accident, generating record revenues of more than R\$1.2 trillion (US\$240 billion) in the five years up to 2023.¹⁵

The steel and mining sectors moreover use an outsized amount of electricity, eating through ~11% national production in 2021, despite only contributing about ~3% of GDP.¹⁶ This could increase competition for electricity between industrial and residential users, feeding into social grievance risks.

9 <https://www.bloomberg.com/news/articles/2025-01-08/brazil-offers-815-million-to-back-strategic-minerals-projects>

10 <https://www.energypolicy.columbia.edu/publications/brazils-potential-role-in-diversifying-us-critical-mineral-supply/>

11 <https://agenciapara.com.br/noticia/60267/setor-mineral-paraense-ultrapassa-marca-de-300-milhoes-de-toneladas-produzidas-aponta-fapespa>

12 <https://www.semanticscholar.org/paper/Keep-the-Amazon-niobium-in-the-ground-Siqueira-Gay-S%C3%A1nchez/b86cbcfde83bd05a1d1dbcd6915c7742a653d4f7>

13 <https://pubs.usgs.gov/periodicals/mcs2025/mcs2025.pdf>

14 <https://www.spglobal.com/commodity-insights/en/news-research/latest-news/metals/081524-lithium-leap-brazil-makes-journey-to-become-a-leading-supplier>

15 <https://observatoriodaminerao.com.br/despite-brumadinho-dam-collapse-the-mining-sector-has-earned-more-than-r1-trillion-in-brazil-since-2019/>

16 <https://observatoriodaminerao.com.br/representando-3-do-pib-setor-minero-siderurgico-consome-11-da-eletricidade-no-brasil/>

Brazil's critical and strategic mineral reserves[^]

Mineral	US ^{^^}	EU ^{^^}	Reserves ('000 tons)	Global Share (%)
Molybdenum			n/a	n/a
Phosphate ^{***}			1,600,000	2.3%
Potassium ^{**}			2,300	0.1%
Sulphur			n/a	n/a
Cobalt ^{**}	Y	Y	11,212	1.6%
Lithium ^{**}	Y	Y	95	0.4%
Nickel ^{**}	Y	Y	16,000	16.8%
Rare Earth Elements ^{**}	Y	Y	21,000	17.5%
Platinum Group Metals	Y	Y	n/a	n/a
Silicon	Y	Y	n/a	n/a
Thallium	Y	Y	n/a	n/a
Tantalum ^{**}	Y	Y	40	28.6%
Tin ^{**}	Y	Y	420	8.6%
Titanium ^{****}	Y	Y	43,000	6.1%
Tungsten ^{**}	Y	Y	28	0.9%
Vanadium ^{**}	Y	Y	120	0.5%
Copper ^{**}	Y	Y	11,212	1.6%
Graphite (Natural)*	Y	Y	70,000	21.9%
Niobium ^{**}	Y	Y	16,000	94.1%
Uranium ^{*****}			245	0.0%
Aluminum (Bauxite)*	Y	Y	2,700,000	8.4%
Iron*			34,000,000	18.9%
Manganese ^{**}	Y	Y	270,000	27.8%
Gold ^{**}			2.4	4.4%

Notes: [^]Brazil classifies minerals as “critical and strategic” based on three criteria:
 (1) Brazil’s competitive advantage in production
 (2) strong demand growth and high import dependence
 (3) domestic reserves considered important for economic development.

^{^^}Classified as critical by the US/EU.

*Mineable mineral reserves

**Mineable metal content

***Mineable reserves of P205 or K20 equivalent

****Mineable reserves of ilmenite and rutile

*****Resources

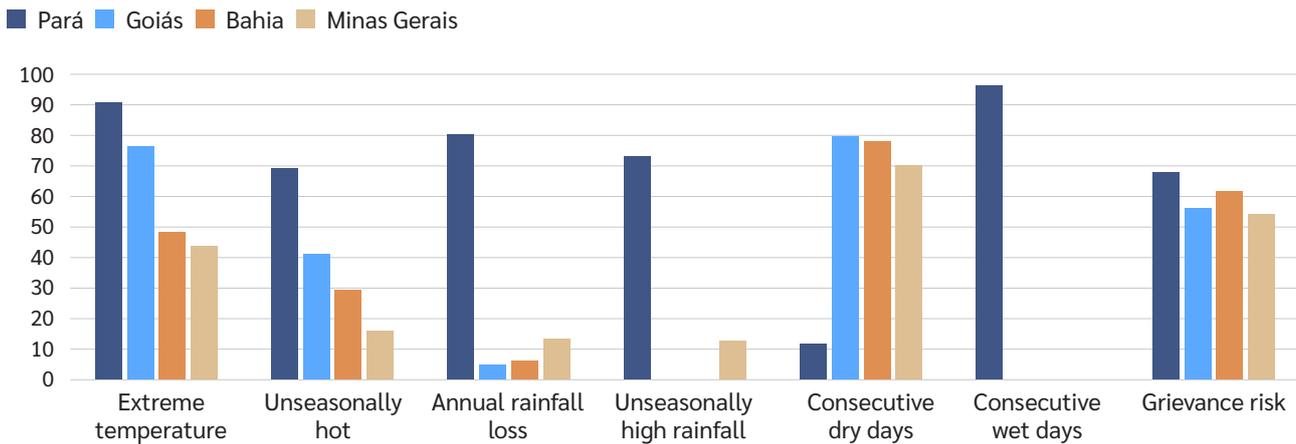
Source: MME, Brazilian Geologic Service (SGB), USGS, European Commission

Climate Risk Assessment: High Risk Exposure

This analysis considered eight climate variables,¹⁷ a unique dataset for social risk,¹⁸ and several hydrological risk datasets¹⁹ to provide a view of cumulative climate risk for four states in Brazil with the largest mining sectors: Pará, Minas Gerais, Goiás and Bahia.

We found that these states are exposed to considerable shifts in climate patterns in the period up to 2030. Specifically, we expect radical changes in temperature and precipitation, both in their extremes and seasonality.

Select climate and social risk factors²⁰



Source: TMP Public

Climate impacts on mining projects, operating areas

Risk Factor	Operational Impact	Cumulative Impact on Operating Areas
Extreme temperatures	Labor disruption; equipment/ infrastructure damage; water scarcity; heat stress; labor disputes	Biodiversity loss; ground hardening; drought; increased run-off from precipitation contributing to flood risk; health and safety risks, damage to livelihoods, social grievances
Unseasonably hot		
Annual rainfall loss	Water scarcity; hydropower shortages; increased competition for resources	Biodiversity loss; ground hardening; drought; increased run-off from precipitation contributing to flood risk; health and safety risks, damage to livelihoods, social grievances
Consecutive dry days		
Unseasonably high rainfall	Labor disruption; floods; landslides, tailing storage failure; mine dewatering issues	Floods; contamination from tailings waste; biodiversity loss; health and safety risks, damage to livelihoods, social grievances
Consecutive wet days		

Table: TMP Public

17 TMP's algorithms assess change in eight climate indicators at 1.5°C of warming (~2029) compared to 1°C (~2017). Indicators are: Extreme temperature (days when temperatures exceed the 95th percentile of the temperature range at 1°C); unseasonably high temperatures; annual rainfall loss; annual dry days; unseasonably high and unseasonably low rainfall; consecutive dry days and consecutive dry days.

18 Our model is based on TMP's Landscape tool, drawing on 14 environmental, social and governance indicators of grievance risk between local communities and companies.

19 Including WRI's Aqueduct 4.0 alongside a Global River Widths (GRWL) remote-sensing database which measures changes to the relative magnitude of river extents between the late 20th and early 21st centuries.

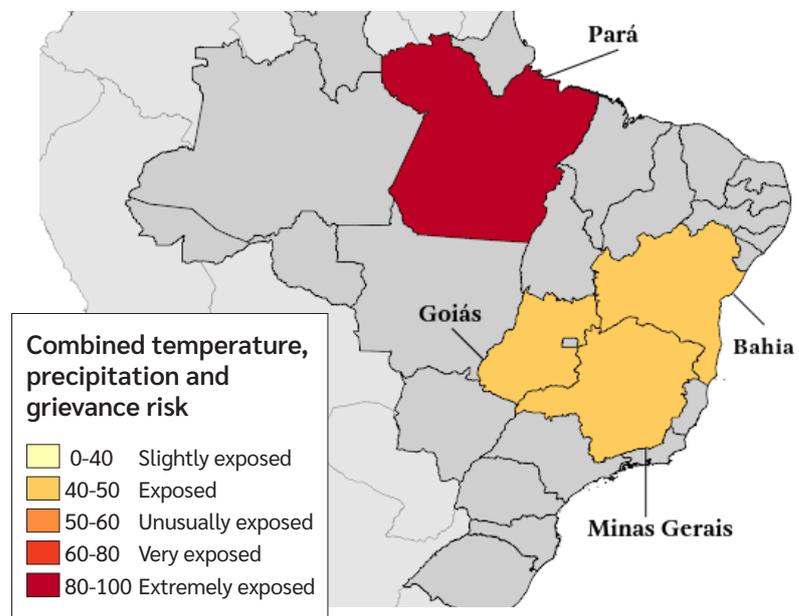
20 Risk exposure is rated on a scale of 0-100. Readings above 80 indicate "extremely exposed"; 60-80 "very exposed"; 40-60 "unusually exposed"; 20-40 "exposed"; and below 40 "slightly exposed."

Elevated conflict, disputes: Without adaptation efforts, these climate impacts could exacerbate existing challenges and disputes between key stakeholders, leading to an increase in violent conflicts, for example.²¹ On the other hand, approaching these challenges through multi-stakeholder collaboration could improve relationships and trust between groups. Rapid action is also needed to protect biodiversity, watersheds and traditional livelihoods from these imminent and extreme climate impacts.

Pará highly exposed:

Our data suggests that Pará state is considerably more exposed to climate risks than Minas Gerais, Goiás and Bahia. This is noteworthy because Pará is one of the largest mining states in Brazil and therefore likely to require more resources for adaptation. Companies and communities are in urgent need of resources to prepare for climate shifts; the data and analysis provided in this report can help inform decisions about how these resources are best allocated.

Combined temperature, precipitation and grievance risk²²



Source: TMP Public

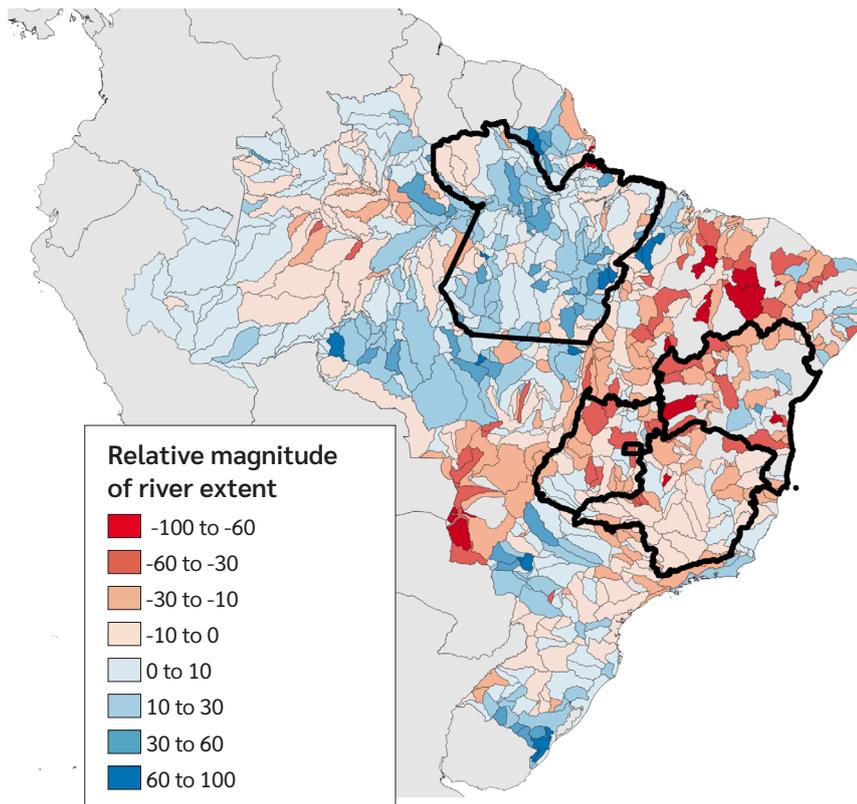
Extreme temperature, grievance risks: Extreme temperature was the highest climate risk factor for all four states along with consecutive wet or dry days (see graph above). Research has found that the proportion of work hours lost to heat stress in Brazil could rise to 0.84% by 2030, above average for South America (0.76%) and almost double from 0.44% in 1995.²³ Pará in particular is exposed to unseasonably high temperatures and rainfall, alongside loss of precipitation. All four areas also have elevated grievance-risk exposure, which reflects challenging operating environments for mine operators and a greater chance of disputes with local communities.

Water stress: Further compounding these climate-related risks, our hydrological analysis revealed that there has been a decline in the extent of rivers in large parts of Minas Gerais, Goiás and Bahia. More specifically, 32-39% of sub-basins in these three states saw a decline in the extent of rivers to a level considered ‘high risk’ (i.e. a decline of more than 10%).

This is likely as a result of growing water demand due to population growth and associated expansion of industrial activities like agriculture, power generation (especially hydropower), and mining.²⁴ Climate impacts on water availability are likely to exacerbate the existing hydrological dynamics detailed above, which could increase competition between these key water users.

21 <https://pmc.ncbi.nlm.nih.gov/articles/PMC6098709/>; <https://greenly.earth/en-gb/blog/ecology-news/does-climate-change-make-conflict-more-likely>
 22 TMP combines and weights our eight climate risk factors and grievance risk to produce a reading on an index of one to 100, giving an indication of exposure to multi-hazard risks.
 23 https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@dgreports/@dcomm/@publ/documents/publication/wcms_711919.pdf
 24 <https://climainfo.org.br/2023/11/12/mineracao-usa-quase-600-bilhoes-de-litros-de-agua-por-ano-sem-indicar-origem/>

Relative magnitude of river extent²⁵



Source: TMP and Watermarq

Erratic precipitation, flooding:

Heavy rainfall can disrupt mine production, causing floods and hampering dewatering efforts. There are numerous examples of mining disruptions caused by heavy rainfall in Brazil, including Vale S.A.'s Mariana complex,²⁶ Vallourec's Pau Branco,²⁷ and Lundin's Chapanda mine.²⁸

Adaptation Paramount

The near-term impacts of climate change on mining and mineral supply chains are widely underappreciated, even by experts. Policymakers and businesses must take urgent action to adapt physical and human infrastructure to avoid the worst impacts of rising global temperatures in the period up to 2030.

While this will require substantial up-front investment, if these steps are not taken we can expect severe disruptions to supply chains that will necessitate larger investments to resolve in the long-run, or could result in stranded assets. This could create a vicious cycle in which lack of adaptation delays mitigation efforts, in turn leading to worse climate impacts and increasing instability.

Mining and Renewable Technologies Important for Emission Reductions

The mining process consumes vast amounts of fossil fuels at every stage and many players in the sector are failing to meet targets set by the Paris Agreement—targets which themselves fall short of what is necessary to limit global warming.²⁹ Numerous companies are also expanding into ecologically sensitive areas, which are important carbon sinks.³⁰

25 The Global River Widths (GRWL) remote-sensing database measures changes to the relative magnitude of river extents between the late 20th and early 21st centuries. Watermarq developed the database using underlying data from: <https://www.nature.com/articles/s41467-023-37061-3>

26 <https://www.miningweekly.com/article/vale-other-brazil-miners-ramp-up-production-as-rains-subside-2022-01-18>

27 <https://www.miningweekly.com/article/vale-other-brazil-miners-ramp-up-production-as-rains-subside-2022-01-26>

28 <https://www.reuters.com/markets/commodities/miners-profits-face-an-unusual-foe-extreme-weather-2022-07-29/>

29 <https://www.weforum.org/stories/2024/02/the-mining-industry-must-be-bold-in-its-support-of-the-race-to-net-zero/>

30 <https://www.wri.org/insights/how-mining-impacts-forests>; <https://www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/Wald/WWF-Studie-Extracted-Forests.pdf>; <https://iucn.org/sites/default/files/2023-11/iucn-cop-28-technical-brief-wcpa-mining-biodiversity-and-protected-areas.pdf>

Mining moreover produces significant volumes of tailings waste - producing one ton of nickel or cobalt generates 100 tons of tailings.³¹ This hazardous waste is stored in tailings pools, posing a risk to surrounding areas if dams fail - which is more likely from climate change-induced high-rainfall events.

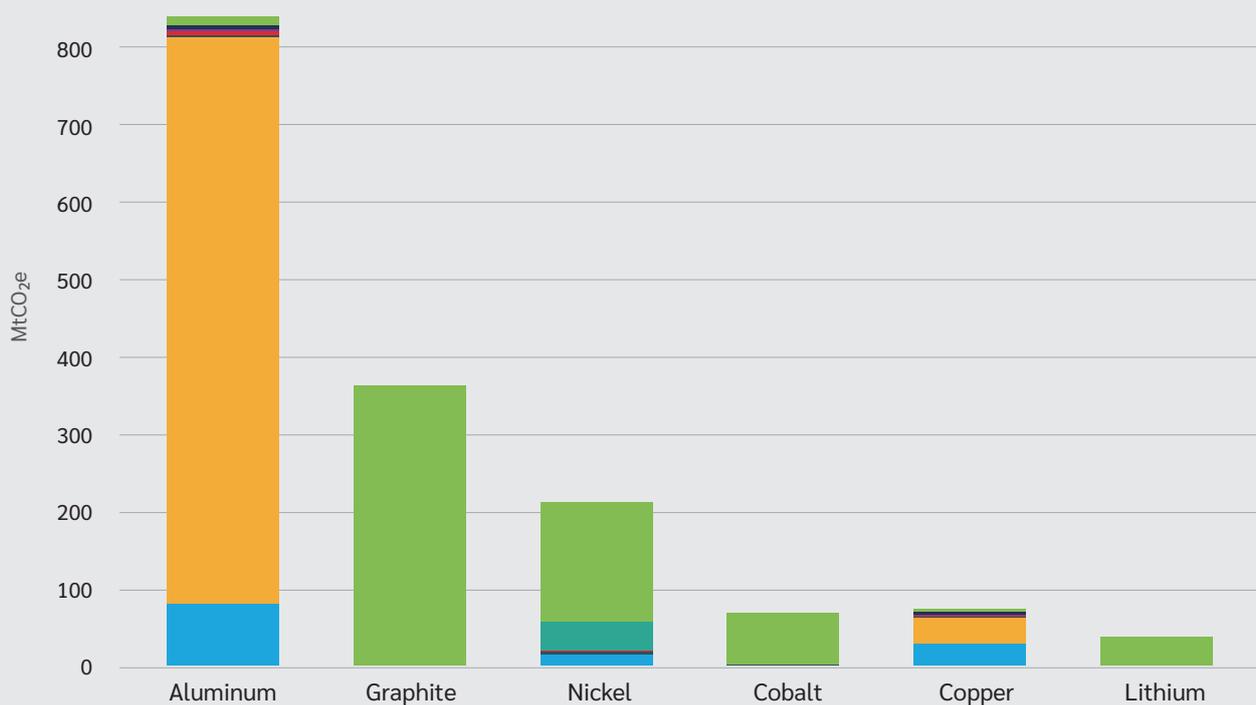
Emissions from the extraction of minerals used in clean energy technologies are often overlooked. These technologies are expected to generate ~16 gigatons of carbon dioxide equivalent emissions (GtCO₂e) by 2050, not including emissions from transporting minerals. This is far lower than the emissions fossil fuels would generate but still comparable to 2018 emissions from the US and China combined.

To ensure the greening of the power sector and battery production, it is essential to address upstream and downstream emissions associated with clean energy technologies through effective policy and innovation. These emissions reductions should be integrated into Nationally Determined Contributions under the Paris Agreement, as urged by the World Bank.³²

Therefore, the mining sector must urgently address scope one, two and three emissions, as well as implement international dam safety standards, such as those proposed by Earthworks and other organizations in Safety First: Guidelines for Responsible Mine Tailings Management.³³ These will be key points of discussion at the upcoming COP30 in Pará.

Cumulative Global Warming Potential from Extraction and Processing of Minerals, Not Including Operations, Using Cradle-to Gate Through 2050 Under 2DS

Energy Storage Geothermal Solar PV Wind Hydro Coral (inc. CSS) Gas (inc. CSS) Nuclear



Note: 2DS = 2-degree scenario, CCS = carbon capture and storage, CSP = concentrate solar power, MtCO₂e = million tons of carbon dioxide equivalent. Data retrieved from the 2019 Global Carbon Atlas: <http://globalcarbonatlas.org/en/CO2-emissions>

31 <https://elements.visualcapitalist.com/visualizing-the-size-of-mine-tailings/>

32 <https://pubdocs.worldbank.org/en/961711588875536384/Minerals-for-Climate-Action-The-Mineral-Intensity-of-the-Clean-Energy-Transition.pdf>

33 <https://earthworks.org/resources/safety-first/>

■ Our Goals

- ▶ Provide communities, companies and governments with state-of-the-art information about shared cumulative climate risks in key mining areas and their social and environmental implications with publicly-available datasets and expert qualitative insights.
- ▶ Facilitate engagement between communities, mining companies and local governments over shared risk factors related to adverse shifts in climate patterns through publications, workshops and table-top exercises.
- ▶ Engage with governments and decision-makers to support policies that encourage climate adaptation measures within key mining areas, including for local communities and mining companies.
- ▶ Catalyze responses and solutions that enable better dialogue and cooperation between mining companies and communities, considering adequate processes of free, prior and informed consent (FPIC) and consultation.

PARÁ STATE

HIGHEST CLIMATE RISK

Pará has some of the richest mineral reserves globally and is among Brazil’s largest producers of TMs. The state’s total mineral output is the second-largest nationally behind Minas Gerais, with extractive industries accounting for 11.5% of GDP.³⁴ Pará is also the most-exposed state in our study to the majority of climate risks we assessed, and has the highest exposure to grievance risk.

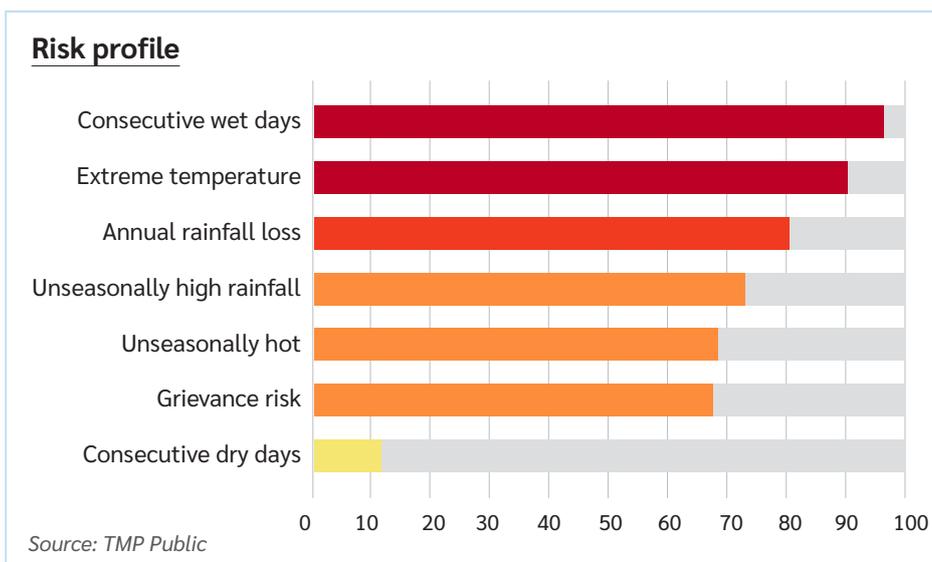
Mineral Output

Pará produced 302.9 million tons of ore in 2023, or 17.7% of national output.³⁵ The state is Brazil’s largest aluminum producer, accounting for 89.4% of national production in 2021. It’s also the country’s second-largest iron ore producer with output of 192.3 million tons in 2021 (33.8% of the national total), following a surge in ore production—annual output doubled from ~200 million to ~400 million tons over the past decade.

Pará also produces copper, kaolin, manganese, nickel, gold and limestone, among other minerals.³⁶ Much of this is exported, mainly to China, Norway, Japan, the US and Malaysia.³⁷ Pará’s extractive industries are concentrated in the municipalities of Canaã dos Carajás, Parauapebas, Marabá, Paragominas and Oriximiná. Major projects in the pipeline include the gold mines Volta Grande (Belo Sun Mining and PA Ressaca) and Coringa (Serabi Gold and PDS Terra Nossa).

High Multi-Hazard Risk

Pará is the most exposed of the four states to the majority of climate risks assessed, including increases in extreme temperatures, unseasonably high temperatures and rainfall, consecutive wet days, and an overall annual loss of rainfall. This reflects significant exposure to multi-hazard risk.



34 <https://www.simineral.org.br/mineracao>

35 <https://agenciapara.com.br/noticia/60267/setor-mineral-paraense-ultrapassa-marca-de-300-milhoes-de-toneladas-produzidas-aponta-fapespa>

36 <https://www.agenciapara.com.br/noticia/47155/boletim-da-mineracao-2023-reforca-a-importancia-da-producao-mineral-paraense-no-cenario-nacional>

37 <https://www.simineral.org.br/mineracao>

Highest grievance risk: Pará is also the most exposed of the four states to grievance-related risks. Evidence suggests that temperature increases are correlated with increased conflict at the national and regional level. Temperature increases may exacerbate grievances, increasing friction between industry and communities, with negative impacts on both sides.

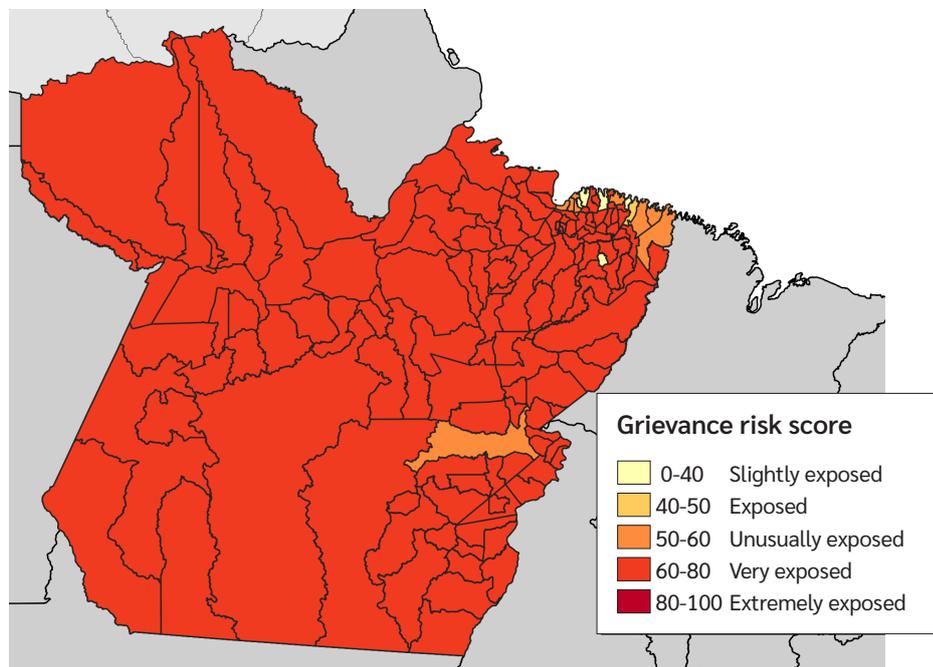
Extreme temperatures can force work stoppages at mining sites, whether because of labor laws, health and safety concerns, or purely physical constraints like heat stroke, so it will be increasingly important for companies to ensure employees are kept safe during heat waves. The International Organization for Standardization (ISO) recommends a wet-bulb temperature threshold of 32°C for mining.³⁸

Erratic precipitation: Notably, Pará is simultaneously exposed to an overall decline in annual rainfall, but also an increase in the number of consecutive wet days and unseasonably high rainfall. This combination of factors suggests that rainfall patterns are becoming more erratic, raising flood risks.

Unusual and high rainfall can force mining operations to stop to avoid tailings failure, address instability of mine slopes, and dewater mining pits. In addition, consecutive rainfall events increase the risk of tailings overflowing or leaking, posing considerable contamination risk to surrounding communities and ecosystems.

Contamination of water resources and environments around mine sites destroys ecosystems and can attract strong opposition from affected communities. This means robust and respectful community engagement practices are key to maintaining social license to operate.

Social risk



Source: TMP Public

On the Ground: Mining Majors Test Regulations

Mining has had profound, negative socio-environmental impacts in Pará, particularly nickel, copper and bauxite projects. Major players involved include Vale S.A. (Brazil), Mineração Rio do Norte (MRN) (Brazil), and Norsk Hydro (Norway).

Vale S.A. operates some of Pará's largest TM projects which are key links in global supply chains. These include the Onça-Puma nickel mine, the Salobo copper-gold mine, and copper operations in Sossego municipality, all located in the Carajás region—also home to the world's largest iron ore mine. Onça-Puma has an annual production capacity of 27k tons of ferronickel and another production line is planned.³⁹

38 <https://www.sciencedirect.com/science/article/pii/S2093791117300562>; https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_711919.pdf; the theoretical limit for human survival is a wet-bulb temperature of around 35°C. This metric includes humidity and is arguably a better measure of human limits to heat exposure than regular temperature.

39 <https://www.brasilmineral.com.br/majores/vale>

Vale's Carajás operations are connected by a 1,000km railroad to neighboring Maranhão state. The socio-environmental repercussions of this logistics corridor have been severe, particularly for the Mãe Maria Indigenous Territory. Local communities along the railroad have reported accidental deaths, health issues caused by noise pollution, and structural damage to their homes. The impact has been exacerbated by Vale's inadequate response and lack of transparency around its environmental impact.⁴⁰

Vale's approach to engaging Indigenous and local communities has drawn criticism for using divide-and-conquer strategies to undermine collective bargaining and exacerbate internal divisions, particularly during the COVID-19 pandemic.⁴¹ Sustainable stainless steel producer Outokumpu (Finland) was formerly a buyer of ferronickel from Onça-Puma but cut ties with Vale in 2024 following reports of the project's socio-environmental impact. However, multinationals from countries such as China, the UK, France, Italy, and Sweden continued to buy nickel from the Onça Puma mine as of 2023.⁴²

In 2021 Vale rescinded all applications for new mines in Indigenous territories, though this move was in part a response to pressure from international stakeholders.⁴³ The company has continued to expand operations surrounding protected areas, while the National Mining Agency (ANM) has reclassified land to allow some operations to continue.⁴⁴

MRN (Brazil), controlled by Swiss trader Glencore since December 2023,⁴⁵ is Brazil's largest bauxite producer and its Oriximiná mine has had a significant socio-environmental impact in Pará. With an annual production capacity of 12.5 million tons, the mine's extensive network of tailings dams⁴⁶ poses grave risks to local quilombola⁴⁷ and riverine communities.

Investigations by TMO found in February 2024 that the company had made over 50 changes to the risk classification and potential associated damage of its dams in the ANM database since 2017.⁴⁸ Lack of transparency around these changes raises questions about the reliability of the classification process along with the integrity of the company's reporting practices and its consultation process.

Historically MRN has had a tense relationship with local communities and lacked transparency around the impact of its operations. Locals have reported water contamination from tailings waste and that the company neglects to monitor its environmental impact on the Saracá-Taquera National Forest.⁴⁹

Norsk Hydro (Norway) operates the Paragominas project, among Brazil's largest bauxite mines with an annual production capacity of 11m tons.⁵⁰ A 244km pipeline that transports slurry from the mine to the Alunorte refinery in the municipality of Barcarena has had a significant impact on local communities and ecosystems, while a tailings dam leak in 2018 contaminated local waterways and sparked a public outcry.

40 <https://observatoriodaminacao.com.br/alongside-the-railroad-of-the-biggest-iron-ore-mine-in-the-world-poverty-pollution-deaths-and-human-rights-violations/>

41 <https://observatoriodaminacao.com.br/divided-by-mining-indigenous-people-in-para-fight-to-maintain-their-identity-against-the-railroad-that-feeds-the-global-steel-industry/>

42 <https://reporterbrasil.org.br/2024/12/multinacional-europeia-deixa-de-comprar-da-vale-por-caso-de-contaminacao-de-rio/>

43 <https://observatoriodaminacao.com.br/o-que-esta-por-tras-da-desistencia-temporaria-da-vale-em-minerar-em-terras-indigenas/>

44 <https://observatoriodaminacao.com.br/apos-anunciar-desistencia-vale-agora-quer-minerar-no-entorno-da-terra-indigena-xikrin-no-para/>

45 <https://observatoriodaminacao.com.br/among-corruption-and-human-rights-violations-swiss-trader-glencore-becomes-main-owner-of-brazilian-aluminum/>

46 <https://www.brasilmineral.com.br/maiores/mrn>

47 Descendants of Afro-Brazilian former enslaved people who established settlements in Brazil after escaping from plantations.

48 <https://observatoriodaminacao.com.br/revealed-records-show-dozens-of-changes-in-mineracao-rio-do-norte-mrn-tailings-dams-in-para-and-communities-fear-disasters/>

49 <https://observatoriodaminacao.com.br/revealed-records-show-dozens-of-changes-in-mineracao-rio-do-norte-mrn-tailings-dams-in-para-and-communities-fear-disasters/>

50 <https://www.brasilmineral.com.br/maiores/hydroparagominas>

Hydro's sustainability claims⁵¹ are at odds with reality and the lived experiences of local communities. Government research institute Instituto Evandro Chagas has found high levels of harmful substances in the local population, including lead, arsenic and even radioactive substances, prompting urgent calls for accountability and reform.⁵²

■ Conclusion

These mining operations continue to cause irreversible socio-environmental impacts while generating bumper profits, underscoring a critical need for efficient regulatory frameworks and corporate accountability. The cumulative impacts of nickel, copper and bauxite mining in Pará illuminate a broader narrative of exploitation that prioritizes profit over people and the planet.

Climate change is likely to exacerbate the socio-environmental impacts of mining, while also making solutions harder to implement in a vicious cycle. Rising temperatures, erratic precipitation, and extreme weather events will not only disrupt mining operations but also magnify existing grievances, compounding pre-existing social tensions and environmental degradation. This highlights the need for urgent and collaborative action to foster a foundation for resilience that we can build on in the coming years.

As decision-makers engage with these issues, understanding the interconnected relationship between climate impacts, local communities, and the ecosystems they depend upon is imperative. Policies should actively incentivize climate adaptation measures that strengthen resilience to multi-hazard risk, while prioritizing corporate transparency, environmental justice, and fair reparations. Strong consultation frameworks are key to ensuring free, prior and informed consent for local communities.

51 <https://www.hydro.com/en/global/sustainability/>

52 <https://amazoniareal.com.br/especiais/barcarena-chernobyl-na-amazonia/>

MINAS GERAIS

HISTORY OF MINING DISASTERS

Minas Gerais has the largest mining industry of any Brazilian state and has seen some of the country's worst socio-environmental disasters: the tailings dam collapses at Mariana in 2015 and Brumadinho in 2019, both involving Vale S.A. The state currently accounts for the majority of Brazil's lithium output, a mineral considered vital for the energy transition. It is also highly exposed to consecutive dry days, which is especially concerning given Brazil's high reliance on hydropower.

■ Mineral Output

Minas Gerais has 620 active mines and the industry contributes ~20% of its GDP.⁵³ Between 2010 and 2020, it accounted for 43.5% of Brazil's mineral production value, generating R\$83 billion in 2020. The state has a long history of mining and its output has surged in recent decades. From 2000 to 2020, production of metallic substances increased 20-fold, and non-metallic substances by 550%.

The state holds 77% of Brazil's iron ore reserves and produces ~192 million tons of the commodity per year, tying with Pará as Brazil's largest-producing state and exceeding the national output of Russia, South Africa and Ukraine.⁵⁴ Minas Gerais also has significant reserves of gold, bauxite, lithium, manganese, niobium, zinc, tantalum and lead.

Major miners with a presence there include Vale S.A. (Brazil), BHP (UK), AngloGold Ashanti (UK), Mosaic Fertilizantes (Brazil), Gerdau (Brazil), Nexa Resources (Brazil), Kinross (Canada), CBA (Brazil), CBMM (Netherlands), Usiminas (Brazil), CSN (Brazil), ArcelorMittal (Canada) and Vallourec (Brazil).

The state contains ~80% of Brazil's lithium reserves and currently accounts for the majority of national production from Vale do Jequitinhonha.⁵⁵ Also known as "Lithium Valley," this project has attracted investment of R\$5.5 billion (~US\$1 billion) since launching on the Nasdaq in 2023, led by Sigma Lithium (Canada) along with Lithium Ionic (Canada), Atlas Lithium (US) and Latin Resources (Australia).

Brazil's government has encouraged the development of the lithium industry since scrapping export restrictions on the commodity in July 2022.⁵⁶ Minas Gerais is home to three of the four projects currently operating in the country.⁵⁷ According to ANM data, the value of the state's lithium output reached R\$1.7 billion in 2022, up 25-fold from R\$68 million in 2019, while annual output of beneficiated lithium roughly tripled over the same period from 47.8k tons to 143.7k tons.

53 <https://www.desenvolvimento.mg.gov.br/assets/projetos/1081/38eb30bbc2960d6b339fb38a60ff66cd.pdf>

54 Minas Gerais contains approximately 77% of Brazil's iron ore reserves with an average iron content of 44.7%; Pará has a low share of reserves (16.3%) but of a higher quality (65.9%). Each state produces ~192 million tons of iron ore per year, together accounting for 49.4% of national production and 8.0% of global production.

55 <https://www.desenvolvimento.mg.gov.br/inicio/noticias/noticia/2432/atra%3F%3Fo-bilion%3Fria-de-investimentos-pelo-vale-do-l%3Ftio-impulsiona-arrecada%3F%3Fo-revertida-em-melhorias-para-a-popula%3F%3Fo>

56 <https://dialogue.earth/en/justice/lithium-valley-brazils-latest-mining-hotspot-stirs-local-concerns/>

57 <https://www.spglobal.com/commodity-insights/en/news-research/latest-news/metals/081524-lithium-leap-brazil-makes-journey-to-become-a-leading-supplier>

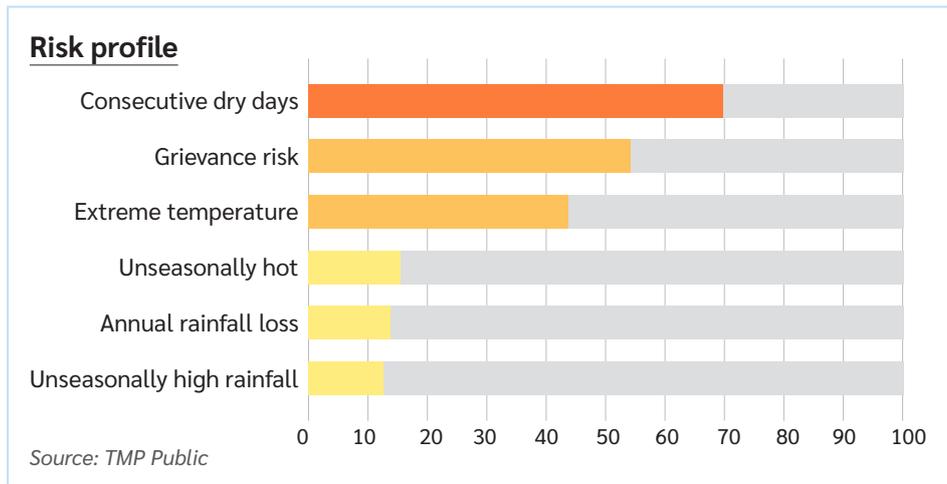
Water Scarcity Risk

The highest risk factor for Minas Gerais is an increase in consecutive dry days. Additionally, 32% of sub-basins in the state have seen a decline in river extent to a level considered 'high risk' (i.e. a decline of more than 10%). These factors point to a growing water scarcity risk.

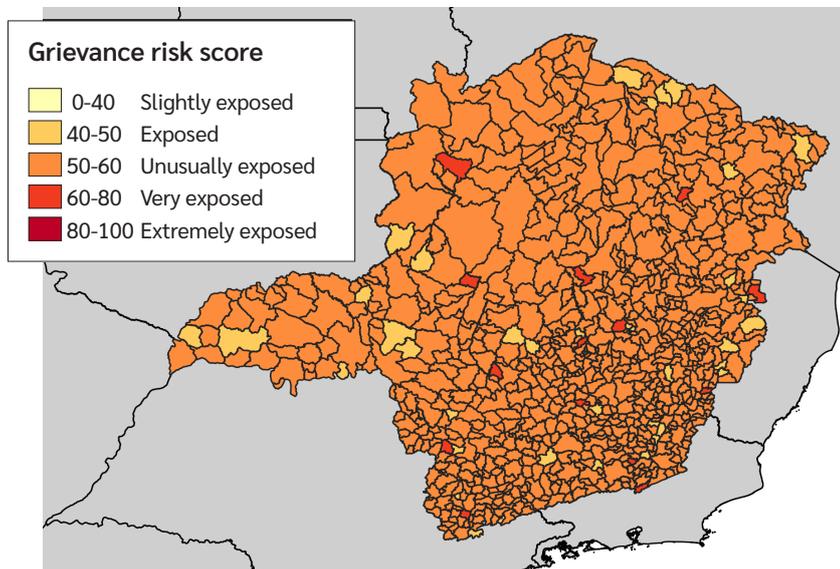
Elevated grievance risk:

Greater water scarcity is likely to disrupt local livelihoods, especially those reliant on natural water resources, such as riverine, fisher people, indigenous communities, and agricultural users. The latter is noteworthy because Minas Gerais has a relatively large agricultural sector, employing over 300,000 people.⁵⁸

This competition for water resources could increase tensions between local communities and mines, which are already large water consumers.⁵⁹ It could also increase tensions between mines and other large water users, like the agricultural and energy industries (particularly hydropower).⁶⁰



Social risk



Fonte: TMP Public

Brazil gets most of its energy from hydropower and Minas Gerais has at least 26 hydropower projects larger than 100MW in operation. An increase in dry days could reduce hydropower production, forcing authorities⁶¹ to choose between powering mines or other major users like the agricultural and residential sectors.

The country came close to rationing electricity amid record-low inflows into hydropower reservoirs in the Southeast and Northeast regions in February 2014 and January 2015.⁶² In August 2024, Brazil switched off two of its largest hydropower plants due to a drought in Porto Velho, Rondonia state that impacted the Madeira River.⁶³ And output from two of the country's newest major hydro plants was

58 <https://portal.datagro.com/en/15/agribusiness/714016/minas-gerais%E2%80%99-agricultural-sector-generates-more-than-1900-formal-jobs-in-july>

59 <https://climainfo.org.br/2023/11/12/mineracao-usa-quase-600-bilhoes-de-litros-de-agua-por-ano-sem-indicar-origem/>

60 <https://fase.org.br/pt/biblioteca/o-que-fica-quando-os-minerios-saem/>

61 <https://www.power-technology.com/news/brazil-cuts-hydropower-use-as-droughts-impact-global-generation/>

62 <https://www.iea.org/reports/climate-impacts-on-latin-american-hydropower/climate-impacts-on-latin-american-hydropower>

63 <https://www.reuters.com/business/environment/northern-brazil-cuts-hydro-power-use-with-prolonged-drought-2024-08-08/>

severely restricted in September 2024 due to low water availability, with the Belo Monte plant operating at just 3% of capacity, and Santo Antônio at less than 10%.⁶⁴

■ On the Ground: Lithium Mining Brings New Risks

Having witnessed two of the worst mining disasters in recent history, Mariana (2015) and Brumadinho (2019), Minas Gerais has become a focal point in discussions about the socio-environmental impacts of the industry. These tragedies highlight the broad risks that mining poses to the environment, climate resilience and local populations. The state is also at the center of Brazil's fast-expanding lithium industry.

Mariana: Operated by Samarco, a joint venture between Vale and BHP Billiton, the Fundão dam in Mariana municipality collapsed in November 2015, releasing more than 50m cubic meters of mining waste into the Rio Doce river.⁶⁵ This destroyed entire communities, including in the neighboring state, and killed 19 people. The environmental damage was extensive, affecting 41 cities, 600km of rivers, and killing 14 tons of fish. The Rio Doce was severely impacted⁶⁶ and efforts to rehabilitate the river, a lifeline for local communities, still have a long way to go.⁶⁷

The judicial process overseeing recovery has been slow. A new agreement for compensation of R\$170 billion (~US\$28 billion) was signed in October 2024,⁶⁸ but the court dismissed criminal charges a few days later.⁶⁹ A lawsuit against BHP in the UK brought by 700k claimants marks a landmark case in corporate accountability⁷⁰ and its outcome could set critical precedents for holding multinational corporations accountable for their environmental impact, both locally and globally. However, a final decision in the case is not expected until April 2025.

Brumadinho: The 2019 collapse of Vale's Córrego do Feijão iron ore tailings dam in Brumadinho Municipality took 272 lives, making it the deadliest labor disaster in Brazilian history.⁷¹ The Paraopeba River was severely polluted, highlighting the inherent dangers of upstream tailings dams.

A reparations agreement was signed in 2021 but issues remain. The compensation package has been criticized as inadequate and prioritizing political interests over reparations and recovery efforts. Courts have favored Vale in 75% of the legal cases brought between 2019 and 2023,⁷² significantly reducing financial compensation for victims, and reflecting the prioritization of corporate interests over those of local communities.

Vale meanwhile continues to downplay the risks associated with its mining operations. A recent investigation revealed that the company was aware of structural issues at the Brumadinho dam, but manipulated safety inspections and claimed it adhered to international standards, misleading investors and local authorities.⁷³

64 <https://www.poder360.com.br/poder-energia/com-seca-belo-monte-gera-menos-de-3-da-energia-projetada/>

65 <https://www.mpf.mp.br/grandes-casos/caso-samarco/o-desastre>

66 <https://www.gov.br/fundaj/pt-br/destaques/observa-fundaj-itens/observa-fundaj/revitalizacao-de-bacias/e-oficial-o-rio-doce-esta-completamente-morto>

67 <https://www.setac.org/resource/progress-on-monitoring-and-rehabilitation-of-the-rio-doce-catchment.html>

68 <https://observatoriodaminacao.com.br/acordo-multibilionario-por-mariana-revela-disputa-acirrada-por-dinheiro-desagrada-a-quase-todos-e-deixa-perguntas-sem-resposta/>

69 <https://observatoriodaminacao.com.br/absolvicao-criminal-pelo-rompimento-de-mariana-e-um-recado-claro-de-que-o-maior-desastre-socioambiental-do-brasil-deve-terminar-em-acordo/>

70 <https://www.revidamariana.com.br/>

71 <https://observatoriodaminacao.com.br/despite-brumadinho-dam-collapse-the-mining-sector-has-earned-more-than-r1-trillion-in-brazil-since-2019/>

72 <https://observatoriodaminacao.com.br/apesar-de-brumadinho-setor-mineral-faturou-mais-de-r-1-trilhao-no-brasil-desde-2019/>

73 <https://observatoriodaminacao.com.br/vale-e-processada-nos-eua-por-mentir-sobre-a-seguranca-de-suas-barragens-antes-de-brumadinho/>

The deadline for the company to complete maintenance work and decommission its hazardous dams has now been extended to 2035, exacerbating ongoing risks in the region. Vale still has 18 dams in Minas Gerais classified as high-risk.⁷⁴

Jequitinhonha Valley: Lithium mining poses additional threats to an area already suffering from extreme poverty and drought. Companies involved in the Jequitinhonha Valley project include Sigma Lithium (Canada), which aims to make Brazil a leader in green lithium production,⁷⁵ Atlas Lithium (US), and Latin Resources (Australia).⁷⁶

However, local communities, including indigenous and quilombola groups, have concerns about the socio-environmental impacts of the project. Companies involved have promised economic benefits to local communities, but a lack of meaningful consultation is fueling concerns over water contamination, deforestation and displacement risks.⁷⁷

Weak consultation, deregulation: Central to all these conflicts is the right to consultation, which is either being conducted superficially or skipped altogether to speed up mining approvals. This disregard for community input is reflected in regulations announced by state governor Romeu Zema in September 2024 which were struck down by a federal judge the following January.⁷⁸

Zema's decree would have left the consultation process in the hands of mining companies rather than an independent third-party,⁷⁹ allowing companies to bypass crucial stages of the consultation process and accelerating mining approvals at the expense of transparency and the environment. This highlights the broader power dynamics at play in Brazil's extractive industries, with commercial interests all too often outweighing the rights of local populations.

■ Conclusion

Minas Gerais stands as a testament to the systemic risks mining poses, not only to the environment but also to public health, local economies, and climate resilience. Mining disasters have had severe cumulative impacts, both on the environment and people.

Against the backdrop of growing demand for TMs, it is crucial that mining practices in Brazil are rigorously scrutinized. The development of the mining industry must be guided by strong accountability, corporate transparency, and fair reparations for affected communities.

74 <https://agenciagov.ebc.com.br/noticias/202310/cresce-para-93-barragens-de-mineracao-que-atestam-estabilidade-informa-anm>

75 <https://sigmalithiumresources.com/sigma-lithium-and-brazilian-government-officials-ring-nasdaq-opening-bell-to-celebrate-the-launch-of-lithium-valley-brazil-initiative/>

76 <https://observatoriodamineracao.com.br/boom-do-litio-no-jequitinhonha-restringe-acesso-a-saude-e-aumenta-o-custo-de-vida-para-a-comunidade-local/>

77 <https://observatoriodamineracao.com.br/boom-do-litio-no-jequitinhonha-restringe-acesso-a-saude-e-aumenta-o-custo-de-vida-para-a-comunidade-local/>

78 <https://www.lex.com.br/stf-suspende-decreto-de-mg-que-restringe-consulta-a-comunidades-afetadas-por-licenciamento-ambiental/>

79 <https://observatoriodamineracao.com.br/governo-zema-e-denunciado-por-decreto-que-compromete-consulta-previa-a-comunidades-tradicionais-e-favorece-mineradoras-em-mg/>

GOIÁS

EXTREME TEMPERATURES, WATER SCARCITY

Located in central Brazil, Goiás is well-positioned as an industrial and commercial hub. Its mineral output is the fourth-largest in Brazil behind Minas Gerais, Pará and Bahia,⁸⁰ and the industry contributes a growing share of state GDP. The Goiás government hopes to leverage geological diversity to build the state into a key supplier of minerals for the energy transition.⁸¹

Goiás has high exposure to consecutive dry days and extreme temperatures, suggesting that water scarcity is a growing risk factor. High temperatures could also disrupt mining activity.

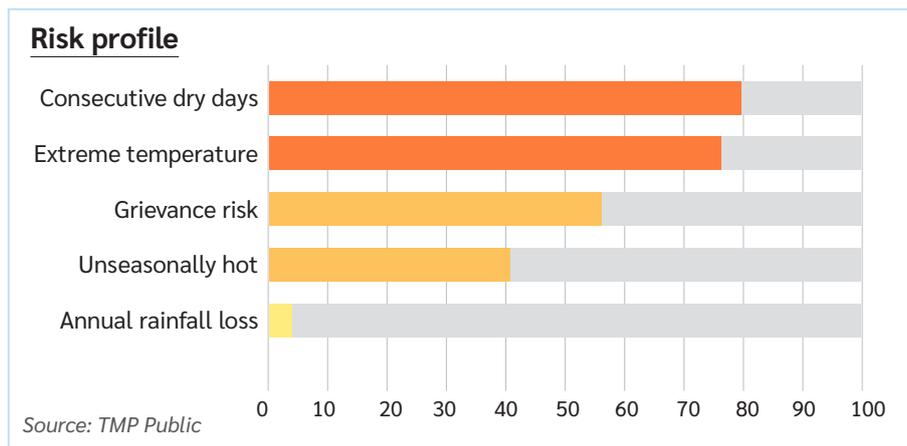
Mineral Output

Goiás is the leading national producer of phosphate, nickel and vermiculite, as well as a producer of copper, gold, bauxite, niobium, chrysotile, agro-minerals, agricultural limestone, and aggregates for the construction industry. The state is also home to one of Brazil’s largest REE projects, Mineração Serra Verde, which entered commercial production in 2023.

Major miners operating in the state include Mineração Maracá (Canada), CMOC Brasil (China), Serra Grande (South Africa), Mosaic Fertilizantes (US), Lundin Mining (Canada), and AngloGold Ashanti (South Africa). Besides the Mineração Serra Verde REE project, dozens of operations are expanding capacity for copper, aluminum, iron, phosphate, granite, manganese, nickel, gold and titanium. Goiás’s mineral exports mainly supply Europe and Asia.⁸²

Extreme Temperature, Drought Risk

Goiás is most exposed to a combination of very hot weather days and an increase in consecutive dry days. In addition, 37% of sub-basins in Goiás have seen a decline in river extent to a level considered ‘high risk’ (i.e. a decrease of more than 10%). This shift towards hotter and drier climate conditions suggests that water scarcity could become a growing concern for mining operations, which are heavy water consumers and compete for this resource with local communities and other industries.



80 <https://www.brasilmineral.com.br/noticias/goias-se-afirma-como-polo-mineral-no-pais>

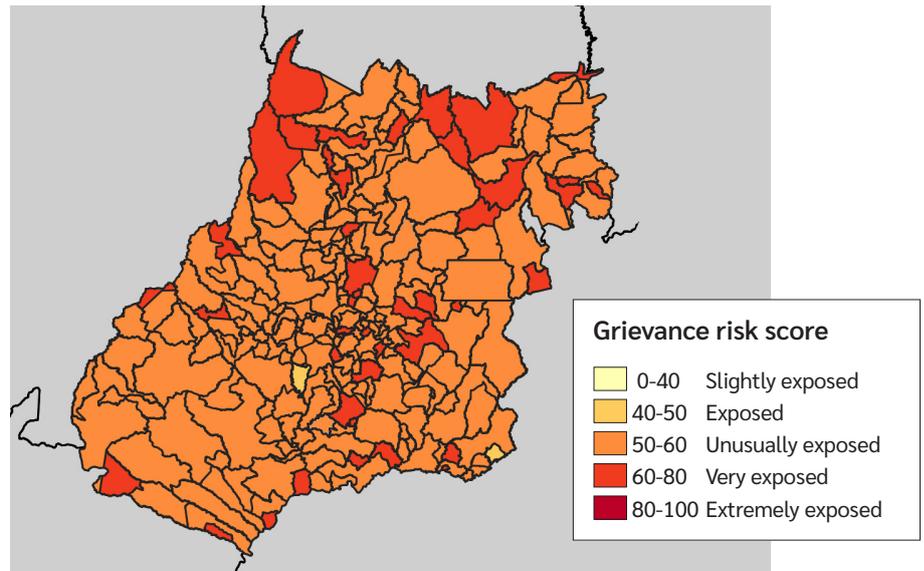
81 https://files.cercomp.ufg.br/weby/up/1364/o/APRESENTACAO-MINERACAO-A4_11-10-2023.pdf

82 https://files.cercomp.ufg.br/weby/up/1364/o/APRESENTACAO-MINERACAO-A4_11-10-2023.pdf

Mining disruptions, grievance

risk: High exposure to extreme temperatures could lead to an increase in the number of days mining staff are unable to work. Increased temperatures could also exacerbate the elevated grievance risk, fueling tensions between mining companies and local communities. This would be detrimental to both groups.

Social risk



Fonte: TMP Public

On the Ground: Vital Ecosystem Services Under Pressure

As a key producer of TMs such as copper, nickel and phosphate, Goiás plays an essential role in Brazil's mining sector. But these operations come at a high environmental cost, threatening biodiversity, water resources and local communities. The impact of mining on agriculture and water systems in Goiás poses both local and national risks. Goiás has 18 dams classified as high-risk, presenting a significant threat to water security in the region.⁸³

Clearing the Cerrado: Formerly ~70% of the state was covered by the Cerrado tropical savanna biome, known as the "cradle of waters" due to its crucial role in Brazil's water cycle.⁸⁴ The Cerrado feeds six of the country's eight major river basins and key aquifers including the Guarani. These rivers provide water for agriculture and energy, as well as drinking water for millions.

However, over 60% of the Cerrado in Goiás has been cleared for agribusiness and urban expansion, exacerbating water scarcity and heightening climate risks. The expansion of mining operations in the state threatens to further disrupt water systems and contribute to deforestation, with tailings dams, water contamination and land dispossession creating risks for local communities and ecosystems.

Mosaic Fertilizantes, one of the world's largest phosphate producers, has extensive operations in Catalão and Ouidor municipalities. Local communities have reported instances of land expropriation and environmental degradation.⁸⁵ The company's product is also intrinsically linked to industrial agribusiness which could further contribute to the destruction of the Cerrado in a vicious cycle.

The company has 12 tailings dams classified as high-risk by ANM, meaning catastrophic environmental impacts if they fail.⁸⁶ Local farmers have reported forcible displacement and land contamination. The area also has high levels of health problems such as respiratory diseases and cancer.⁸⁷

83 <https://www.impresadocerrado.com.br/materia/1945/goias-tem-18-barragens-criticas-diz-relatorio-da-ana>

84 <https://ispn.org.br/biomas/cerrado/berco-das-aguas/>

85 <https://observatoriodamieracao.com.br/mosaic-fertilizantes-expulsa-moradores-de-suas-casas-em-goias-para-armazenar-rejeitos/>

86 <https://observatoriodamieracao.com.br/uma-das-maiores-produtoras-de-fosfato-do-mundo-mosaic-fertilizantes-tem-12-barragens-de-alto-risco-no-brasil/>

87 <https://observatoriodamieracao.com.br/gigante-americana-mosaic-fertilizantes-entra-em-conflito-com-agricultores-em-mg-e-em-goias-enquanto-expande-suas-atividades/>

CMOC's niobium mine near the city of Catalão has caused health issues in the area and contributed to conflicts over land and water. The company's niobium and phosphate projects have displaced traditional communities and worsened socio-environmental vulnerabilities. Pressure on local water resources has increased, with local residents reporting contamination and a lack of adequate compensation.⁸⁸

Maracá, owned by Canada's Lundin Mining, operates the Chapada copper-gold mine in Alto Horizonte municipality. The mine's tailings dam is classified as high-risk and has been linked to heavy metal contamination in the Formiga River, causing widespread fish die-offs and chronic illnesses in local communities.⁸⁹

■ Conclusion

Mining in Goiás presents a direct threat to the Cerrado's unique ecosystem, with cascading effects on water resources, biodiversity, and climate resilience. The high risk of dam failures, contamination of vital water supplies, and the displacement of local communities underscores the need for strict oversight and socio-environmentally responsible management practices.

Protecting the Cerrado from further degradation is crucial to preserve biodiversity, ensure water security, and mitigate climate risks nationally. The ongoing expansion of mineral extraction, particularly the state's efforts to develop its TM resources, must be balanced with strong environmental safeguards to prevent irreversible damage to one of Brazil's most vital biomes.

88 <https://observatoriodaminerao.com.br/gigante-americana-mosaic-fertilizantes-entra-em-conflito-com-agricultores-em-mg-e-em-goias-enquanto-expande-suas-atividades/>

89 <https://www.jornalopcao.com.br/ambiente/goias-tem-18-barragens-de-risco-elevado-e-um-rio-ja-contaminado-422154/>

BAHIA

WATER SCARCITY RISK

Bahia has Brazil’s third-largest mining industry and the largest state economy in the Northeast, contributing more than 4% to Brazil’s GDP.⁹⁰ The state has extensive infrastructure with the second-longest road network in Brazil, the third-largest airport capacity, and three ports (Salvador, Aratu and Ilhéu). A large solid bulk port is also under construction (Porto Sul in Ilhéus) which will service the extractive industries and has sparked concerns over its environmental impact.

Bahia has high exposure to consecutive dry days, suggesting an elevated risk of water scarcity. This could in turn exacerbate grievance risk, which is also relatively high.

Mineral Output

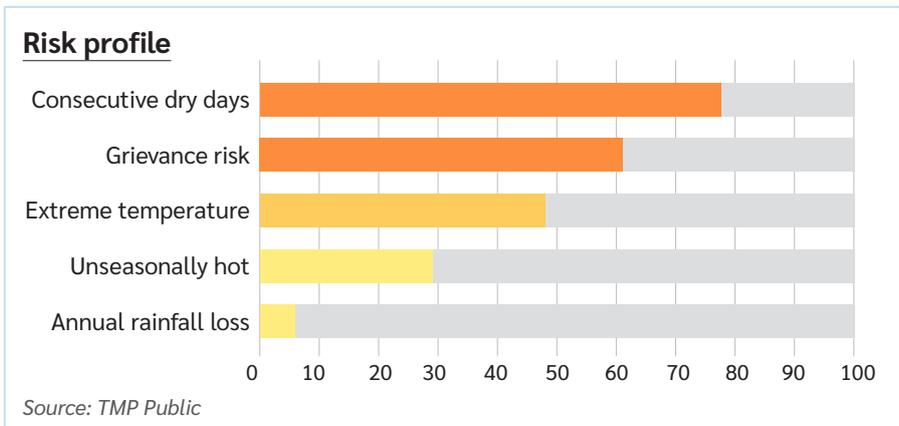
Bahia’s government has encouraged the growth of its mining industry in the name of “technological development” and claims to have conducted the most extensive geological studies of any Brazilian state. It invested more than R\$1.8 billion in mineral research from 2010 to 2020, by far the most of any Brazilian state, with the lion’s share going to copper, gold and nickel.⁹¹

The government has focused on finding new deposits, especially of commodities necessary for the energy transition including copper, lithium, graphite, nickel and cobalt, as well as REEs and platinum group metals (PGMs). The top three minerals produced by the state are gold (27%), nickel (19%) and copper (17%) and its main export destinations are Asia (China), Europe and North America.⁹²

Major miners operating in the state include Bahia Mineração (BAMIN) (owned by Luxembourg-headquartered Eurasian Resources), Equinox Gold (Canada), Ero Brasil Copper (Brazil), Mineração Caraíba (Brazil) and Largo Vanádio (Brazil).

Water Scarcity, Social Grievance Risk

Bahia is exposed to an increase in consecutive dry days, and 39% of sub-basins in the state have seen a decline in river extent to a level considered ‘high risk’ (i.e. a decrease of more than 10%). This suggests that water scarcity is likely to become a growing risk for mining companies and local communities.



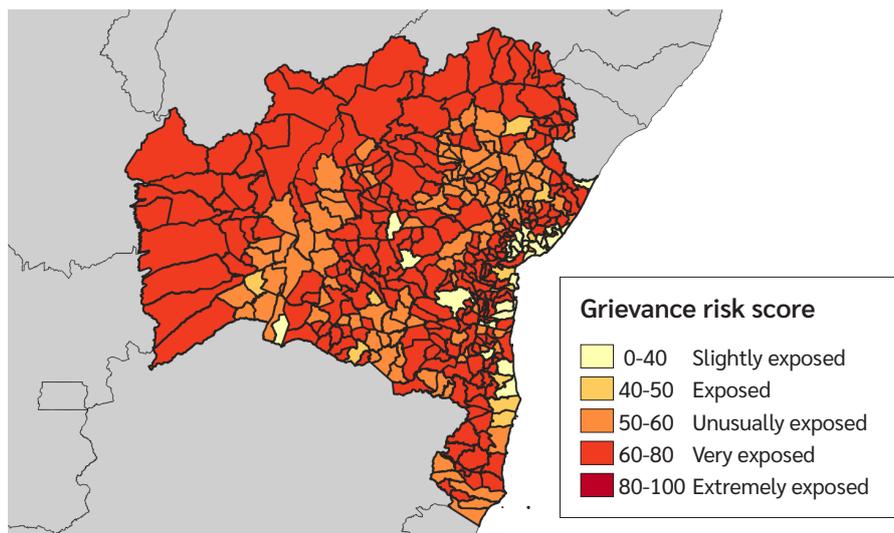
90 http://www.cbpm.ba.gov.br/wp-content/uploads/2024/05/Folder-Bahia-de-todos-os-minerios_port_Ing.pdf

91 <https://observatoriodaminerao.com.br/governo-da-bahia-gastou-r-600-milhoes-em-pesquisa-mineral-nos-ultimos-2-anos-crise-climatica-pode-se-agravar/>

92 http://www.cbpm.ba.gov.br/wp-content/uploads/2024/05/Folder-Bahia-de-todos-os-minerios_port_Ing.pdf

Social risk

Given the state is also exposed to high grievance risks, mining companies operating there will need to closely monitor the effects of their projects on water availability in surrounding communities to avoid potential competition and disputes over resources.



Source: TMP Public

On the Ground: Atlantic Forest Under Threat

Some mining operations are concentrated in the south of Bahia, an area frequently affected by heavy rains, exacerbating potential contamination and flooding risks for industry, surrounding people and forest ecosystems. The state government continues to support the expansion of the sector with major projects such as Porto Sul and the revival of uranium mining in the region, posing a threat to the important Atlantic Forest ecosystem.

Porto Sul: Run by BAMIN, this project encompasses a vast port complex in Ilhéus, an iron ore mine in Caetitê municipality, and the West-East Integration Railway (FIOL). Scheduled to commence operations in 2026, the port aims to export up to 42 million tons of commodities annually, including iron ore and grains, to countries including China. However, ongoing construction has had severe socio-environmental impacts, leading to springs drying up and destruction of the Atlantic Forest ecosystem.⁹³

Eucalyptus plantations: There are also extensive eucalyptus plantations in the region, an invasive species that has been linked to “greenwashing”.⁹⁴ These plantations are mostly owned by Suzano, a leading global pulp and paper producer, and have had a range of socio-environmental impacts, raising tensions with local communities. Additional pressure on infrastructure that is shared with mining operations also affects local communities, as observed along the railway that connects Vale’s Carajás operations to the state of Maranhão.

Brazil Iron, owned by a British holding company, has caused environmental degradation in the Chapada Diamantina region, silting up springs and spreading toxic dust in local coffee and sugarcane plantations. Community associations allege that the company is unwilling to listen to their complaints.⁹⁵

The region is renowned for its high-quality coffee and cachaça⁹⁶—coffee from Piatã municipality has won major international awards. Mining is in tension with these thriving local industries, competing with them for water, land and infrastructure resources. Brazil Iron has filed 25 mineral research requests with ANM, all in

93 <https://mapadeconflitos.ensp.fiocruz.br/conflito/ba-populacao-de-ilheus-denuncia-empresendimentos-de-viabilidade-socioambiental-duvidosa/>

94 <https://www.dw.com/en/greenwashing-brazils-sustainable-paper-company-eucalyptus-pulp-producer-suzano/a-65724286> ; <https://www.dw.com/en/brazil-the-rise-and-risks-of-green-eucalyptus-charcoal/a-68003328>

95 <https://observatoriodaminerao.com.br/mineradora-inglesa-viola-direitos-quilombolas-na-chapada-diamantina-na-bahia/>

96 A distilled spirit made from fermented sugarcane juice.

the Chapada Diamantina region, and already has authorization to extract up to 600,000 tons of iron ore per year, despite its projects being at a research stage.

Brazil Iron moreover has a history of environmental violations. In 2022, the Bahia Environment and Water Resources Institute (INEMA) suspended activities at the company's Fazenda do Mocó Mine after identifying violations such as the suppression of vegetation cover, incompliance with environmental regulations, and unauthorized activities and construction.

■ Conclusion

Given the severe environmental impacts of Brazil Iron's operations and eucalyptus plantations in Bahia, the state government's efforts to further expand the mining sector and related infrastructure projects such as Porto Sul highlight the need for a strong regulatory framework to mitigate socio-environmental impacts. This must include thorough consultations with local communities, in particular to minimize the impact of mining operations on thriving local industries such as coffee and cachaça. The resumption of uranium mining in the area is another concerning development that necessitates strict oversight.

KEY RISKS

People, communities and the environment

- **Violation of land and water rights:** Mining activities often result in land grabs, forced displacement, and the contamination of water sources essential for indigenous, quilombola, and riverine communities, directly threatening their food security and livelihoods.
- **Disregard for free, prior, and informed consent (FPIC):** Communities frequently report inadequate or absent consultation processes and even coercive agreements, violating their rights to self-determination and decision-making over ancestral lands.
- **Public health risks:** Mining generates air, noise, and water pollution, exposing communities to hazardous materials like heavy metals and radioactive elements, which can lead to long-term health issues, including respiratory and chronic illnesses.
- **Abandoned tailings dams:** Improperly managed or abandoned tailings dams pose ongoing threats to communities, including the risk of catastrophic failures and contamination of local waterways.
- **Cultural and social risks:** The degradation of ecosystems disrupts traditional ways of life, erodes cultural practices tied to the land, and weakens the social fabric of communities reliant on subsistence activities.

Nature and ecosystems

- **Ecosystem degradation and biodiversity loss:** Climate change poses a significant risk to Brazil's rich and fragile ecosystems, such as the Amazon rainforest, the Cerrado and the Atlantic Forest. Countless plant and animal species are at risk of extinction, which could further reduce ecosystem resilience and adaptability to climate change.
- **Cumulative impacts on ecosystem services:** Beyond local impacts, the cumulative effects of mining weaken ecosystem services essential for regional and global stability, such as carbon sequestration, water regulation, and soil fertility.
- **Water cycle disruption:** Deforestation and land degradation caused by mining interfere with regional hydrological systems, affecting rainfall patterns and exacerbating droughts that compromise water availability and food security.
- **Intensification of climate change:** By damaging vital carbon sinks like the Amazon and emitting greenhouse gases through deforestation and energy-intensive extraction processes, mining contributes to global climate imbalances.
- **Abandoned tailings dams:** Disused and poorly monitored mining infrastructure, such as tailings dams, poses severe environmental hazards, including the risk of toxic spills that contaminate soils, rivers, and aquifers.

Investors and companies

- **Increased flooding** due to erratic precipitation is a major risk for mining operations. Besides disrupting production, it raises the risk of tailing pool overflows and dam failures that could contaminate the surrounding environment and communities.
- **More frequent droughts** could increase pressure on water resources that are shared with other users. Given Brazil's high dependence on hydropower, this could have a knock-on effect on electricity supply. Dry conditions also harden the ground and increase run-off from precipitation, feeding back into flood risks.

- Social grievance risks are likely to be heightened by climate change, with mining operations impacting the environment and competing with local communities for increasingly scarce resources. This raises conflict and dispute risk, highlighting the importance of thorough consultations with local communities prior to starting or altering any projects, as well as adequate reparation processes with fair compensation for any adverse effects.
- Substantial upfront investment may be necessary to manage these risks and adapt to climate change, but failing to do so risks severe economic consequences in the long-term.

RECOMMENDATIONS

Local actors

1. **Safeguard consultation processes:** Ensure meaningful and ongoing consultations with impacted communities, including indigenous, quilombola, and traditional populations, following the principles of FPIC to mitigate conflict and respect local autonomy. FPIC processes must precede any request for mineral exploration, including research, as well as all operational changes, including unforeseen developments.
2. **Strengthen environmental oversight:** Enhance local monitoring of environmental impacts from mining and commercial plantations, reinforcing agencies' capacity to hold companies accountable and ensuring regular public reporting of socio-environmental risks.
3. **Invest in health and environmental safety:** Facilitate health assessments and ongoing monitoring for communities near mining sites, particularly in regions with deposits of uranium or other hazardous materials. And create a mechanism to provide accessible, transparent information on water and air quality.
4. **Foster collaboration between municipalities:** Create a regional platform for local governments, community leaders, and civil society organizations to coordinate responses to the socio-environmental impacts of mining and industrial monocultures, fostering knowledge sharing and policy alignment. Improve preventative measures through knowledge transfers from regions that have already been impacted by mining.

National actors

1. **Strengthen environmental regulation:** National agencies should revise and improve regulatory frameworks for mining, particularly in sensitive ecosystems like the Amazon, Cerrado and Chapada Diamantina, and ensure strict enforcement to deter violations and prevent widespread environmental damage.
2. **Establish policies to protect affected populations:** This should include completing the demarcation of indigenous and quilombola territories, as well as formal land titling for rural communities and increased legal support to safeguard their rights.
3. **Promote economic alternatives:** Support the diversification of economies while accounting for local cultural concerns and protecting biodiversity. Promoting community-based forest initiatives and ecotourism can help reduce dependency on extractive industries.
4. **Enhance monitoring and transparency mechanisms:** Increase funding and capacity for agencies like IBAMA and state environmental bodies to conduct independent inspections, establish transparent reporting systems, and make environmental data accessible to affected populations.

International actors

1. **Support research and monitoring of global climate impacts:** Fund collaborative research focused on the global climate impact of TM extraction, emphasizing cumulative effects in key biomes such as the Amazon and Atlantic Forest. This research could inform international climate agreements and highlight Brazil's role in climate adaptation.
2. **Demand compliance with human rights standards:** Foreign governments and corporations with mining investments in Brazil should require adherence to international human rights and environmental standards, including supply chain due diligence to prevent mining-related impacts such as deforestation and water pollution.
3. **Promote international exchanges on climate justice:** Encourage the inclusion of regional actors from affected areas in international forums, fostering dialogue on best practices and reinforcing Brazil's obligations under international environmental, climate and human rights agreements.
4. **Encourage risk management:** Highlight the economic benefits of preemptive risk management for governments and businesses in order to encourage best practices and avert environmental problems.