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Review paper

THE GLOBAL IMPACT OF CLIMATE CHANGE ON THE MINING SECTORINSTRUCTIONS

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Abstract
Climate change poses a profound and multifaceted challenge to industries worldwide, and the mining sector is no exception. As a foundational industry for global development, providing essential raw materials for everything from infrastructure to renewable energy technologies, mining is simultaneously a significant contributor to greenhouse gas emissions and highly vulnerable to the physical impacts of a changing climate. Extreme weather events, shifting precipitation patterns, and rising temperatures directly affect mining operations, supply chains, and the communities in which mines operate. This paper explores the complex interplay between climate change and the global mining industry, examining its climate footprint, vulnerabilities, and the critical role it plays in both contributing to and adapting to a changing world. It will also highlight the need for proactive strategies and international cooperation to foster a more resilient and sustainable mining sector globally.
Keywords: *climate change, mining, globally*

1. THE CLIMATE FOOTPRINT OF MINING

The mining sector is inherently energy-intensive, making it a significant contributor to global greenhouse gas (GHG) emissions. The total carbon dioxide (CO2) emissions from mining operations vary considerably depending on the type of resource being extracted and the specific mining processes employed, such as open-pit versus underground mining. For instance, coal mining, while providing a substantial portion of the world's primary energy demand, contributes to global warming not only through the combustion of coal but also through fugitive emissions released during the extraction process.

Historically, mining has relied heavily on fossil fuels for power generation, transportation, and heavy machinery. As readily accessible, high-grade ore deposits become scarcer, mining operations are forced to extract from deeper and lower-grade reserves. This trend necessitates increased energy consumption, greater water usage, and the generation of larger volumes of mine waste, thereby expanding the industry's overall climate footprint [1].

Recent data indicates that the mining sector continues to face pressure to reduce its emissions. While the provided 2016 report highlights efforts by some companies to trap fugitive emissions and explore renewable energy options, particularly in regions like Chile, the overall progress in decarbonization remains a critical area of focus. The push for electrification of mining equipment, adoption of renewable energy sources (solar, wind, and geothermal), and improvements in energy efficiency are key strategies being pursued to mitigate the sector's climate impact. However, the scale of these efforts needs to accelerate to align with global climate targets.

2. VULNERABILITY OF THE MINING INDUSTRY TO CLIMATE CHANGE

The mining industry is particularly vulnerable to the direct and indirect impacts of climate change due to its inherent dependence on natural environmental conditions and its fixed geographical locations. Unlike some other industries, mining operations cannot simply relocate if environmental conditions become unfavorable. The long-term viability of mining operations is directly tied to factors such as a habitable climate, access to water resources, and supporting infrastructure.

Climate change manifests its impacts on mining through various pathways:

- Water-related impacts: This includes increased frequency and intensity of droughts, floods, cyclones, and storms. Droughts can lead to water scarcity, impacting ore processing, dust suppression, and even causing temporary shutdowns. Conversely, extreme rainfall and floods can inundate open-pit mines, damage infrastructure, and lead to the overflow of tailings dams, releasing contaminated materials into the environment. The 2010-2011 floods in Queensland, Australia, for instance, caused significant losses to the coal mining sector, highlighting the economic vulnerability to such events [2,3].
- Heat-related impacts: Rising temperatures can lead to heat stress for workers, increasing health and safety risks and potentially reducing productivity. Bushfires, often exacerbated by hotter and drier conditions, can also threaten mining sites and infrastructure.
- Sea-level rise: For coastal mining operations, rising sea levels pose a direct threat of inundation and increased saltwater intrusion, affecting freshwater sources and infrastructure.

Many of the world's largest mining operations are located in remote, climate-sensitive regions, such as the Gobi Desert in Mongolia or the Atacama Desert in Chile. These regions are already experiencing significant climatic shifts, making mining operations there increasingly precarious. The complex interplay of these impacts can create second-order effects, making it challenging for the industry to ascertain and address the full scope of risks in the short term [4].

Beyond operational risks, climate change also poses significant reputational risks to mining companies. Mismanagement of climate-related impacts, such as tailings dam failures due to extreme flooding or competition over scarce water resources with local communities during droughts, can severely damage a company's social license to operate and investor confidence. This growing awareness of climate vulnerability is pushing the industry to seek adaptive measures to maintain functionality and longevity.

3. MINING AND DEVELOPMENT IN A CHANGING CLIMATE

The extractives sector plays an indispensable role in the economic development models of many regions and countries, particularly in developing and emerging economies. It often serves as a primary pathway for poverty alleviation and economic growth, offering significant potential for quick returns on investment. However, for these positive effects to materialize, mining operations must adhere to international performance standards and operate within robust regulatory environments.

In the absence of such preconditions, mining can bring a suite of enduring costs and impacts throughout its lifecycle. These challenges extend beyond disciplinary boundaries, encompassing social, cultural, environmental, economic, and institutional concerns that fundamentally influence sustainable development pathways. Key impacts often include changes to labor patterns, influx of transient workforces, income inequality, conflicts, human rights issues, inequitable redistribution of profits, loss of ancestral lands, and gendered effects [5,6,7].

Crucially, there is a recognized knowledge gap regarding the specific connection between climate change and natural resource development in developing countries, which are projected to experience greater vulnerability to climatic shifts. While mining offers a significant development pathway, it also carries the potential to exacerbate changes in natural environmental conditions, for example, by restricting access to land and water. This can disrupt traditional, resource-dependent livelihoods such as herding, agriculture, and fisheries.

Furthermore, many developing nations already face challenges with limited technical and financial resources for climate adaptation. This makes it even more critical to understand and integrate the complex interlinkages between the extractives sector and climate change into policy and strategic decision-making. The case study of Mongolia, for instance, highlights how a rapidly expanding, water-intensive mining industry in a climate hotspot experiencing reduced rainfall can intensify competition over already compromised water sources, potentially leading to long-term conflicts between various actors [8,9]. This underscores the need for responsible mining practices that consider both economic development and environmental sustainability in the face of climate change.

4. SUPPLY CHAIN RISKS AND SECURITY OF SUPPLY

Global supply chains for minerals and metals are increasingly exposed to climate-related risks, impacting both developed and developing nations. Countries heavily reliant on the mining sector for their development, as well as industrialized nations dependent on a secure and stable supply of resources, share these vulnerabilities. Climate change acts as a multiplier effect on existing supply chain risks, adding complexity and intensifying or altering existing threats.

These risks include disruptions caused by extreme weather events, such as floods, droughts, and storms, which can halt production, damage infrastructure, and impede transportation. Beyond physical disruptions, political and policy reactions to climate risks, such as export bans or tariffs aimed at promoting domestic supply, can also destabilize global supply chains. The volatility in commodity prices, while influenced by various factors, can be exacerbated by climate-induced supply shocks.

Resource extraction is becoming more challenging and expensive due to declining ore grades and the increasing necessity to operate in more fragile regions, which in turn elevates political risks. These factors contribute to supply inelasticity, making it harder to quickly increase supplies in response to demand, thereby driving price volatility [10].

Factors such as regulations and policies, prices, tariff and non-tariff trade barriers, development levels and changing life styles are usually not considered (European Commission 2014b), figure 1.

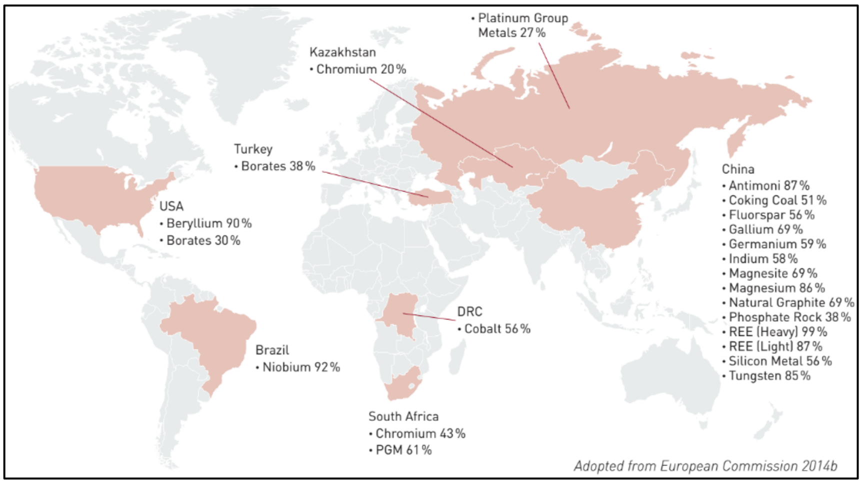

Figure 1. EU critical minerals: World primary supply of the 20 critical raw materials

In addition, these methodologies often do not take into account whether a mining operation is located in regions with increased seismic risks, water stress or ecologically sensitive regions [11].

The same is true for climate change and how it will impact individual mining areas, which in most cases is not included in criticality assessments [12].

Efforts are underway internationally to improve governance around mineral supply chains, particularly concerning high-risk and conflict areas. However, there has been limited systematic integration of a 'climate' focus into these discussions. Given that a significant and growing proportion of extractive resources originate from developing nations—which often lack adequate resources for climate adaptation—there is an urgent need for robust measures to ensure climate-resilient supply chains. This includes improved due diligence mechanisms that assess potential impacts from climatic changes across all stages of the supply chain, from mineral extraction to product manufacturing and distribution.

5. CONCLUSION

The global mining sector stands at a critical juncture, facing unprecedented challenges and opportunities presented by climate change. While mining is essential for providing the raw materials necessary for modern society and the transition to a low-carbon economy, its operations are simultaneously a significant source of greenhouse gas emissions and highly susceptible to the physical impacts of a changing climate. Extreme weather events, water scarcity, and rising temperatures pose direct threats to operational continuity, supply chain stability, and the social license to operate.

Addressing these complex interdependencies requires a multi-faceted approach. Decarbonization of mining operations through the adoption of renewable energy, improved energy efficiency, and technological advancements is crucial to mitigate the sector's climate footprint. Simultaneously, robust adaptation strategies are necessary to enhance the resilience of mining infrastructure and operations to the inevitable impacts of climate change. This includes advanced water management systems, climate-proof infrastructure design, and effective disaster preparedness.

Furthermore, the role of foreign policy and international cooperation is paramount in fostering responsible mining practices globally. Integrating climate risks into critical minerals policies, improving social and environmental standards across the extractive sector, and supporting national and regional dialogues on sustainable mining are vital steps. By proactively addressing climate change, the mining industry can not only safeguard its future but also contribute significantly to global efforts in building a more sustainable and resilient world.

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REFERENCES

[1] G.M. Mudd, Z. Weng, R. Memary, S.A. Northey, D. Giurco, S. Mohr, L. Mason, 2012: Future greenhouse gas emissions from copper mining: assessing clean energy scenarios. Study prepared for CSIRO Minerals Down Under Flagship by Monash University and Institute for Sustainable Futures, UTS.

[2] QFCI [Queensland Floods Commission of Inquiry] 2012: Final report, Volume 2. Brisbane, Australia.

[3] ABARES [Australian Bureau of Agricultural and Resource Economics and Sciences] 2011: The impact of recent flood events on commodities: Special report. Canberra: Australian Bureau of Agricultural and Resource Economics and Sciences.

[4] R. Gledhill, D. Hamza-Goodacre, L.P. Low, 2013: Resilience: A journal of strategy and risk. Retrieved 11 December 2015 from http://www.pwc.com/gx/en/governance-risk-compliance-consulting-services/resilience/publications/pdfs/issue3/business_not_as_usual.pdf.

[5] F. Solomon, E. Katz, R. Lovel, Res. Policy 33 (2008) 142-149.

[6] C. Hill, K. Newell, 2009: Women, communities and mining:the gender impacts of mining and the role of gender impact assessment. Carlton: Oxfam Australia
[7] D. Kemp, C.J. Bond, D.M. Franks, C. Cote, J. Clean. Prod. 18:15 (2011) 1553-1562.
[8] C. Upton, 2012: Mining, resistance and pastoral livelihoods in contemporary Mongolia. In: Dierkes, J. (ed.): Change in Democratic Mongolia: social relations, health, mobile pastoralism, and mining. Leiden: Brill, pp. 223-248.
[9] J. Wang, D.G. Brown, A. Agrawal,: Glob. Environ. Change, 23 (6) (2013) 1673-1683
[10] World Bank 2014: Commodities Market Outlook October 2014.Retrieved 11 December 2015 from http://www.worldbank.org/content/dam/Worldbank/GEP/GEPcommodities/commodity_markets_outlook_2014_october.pdf.
[11] R. Vogt, 2015: Ökologische Effekte bei der Gewinnung abiotischer Rohstoffe in Deutschland und weltweit.Conference: Ressourcen schonen – biologische Vielfalt erleben, Frankfurt/Main, 25.03.2015.
[12] L. Mason, D. Giurco, 2013: Climate change adaptation for Australian minerals industry professionals. Final Report. National Climate Change Adaptation Research Facility. Retrieved 7 June 2015 from http://www.nccarf.edu.au/sites/default/files/attached_files_publications/Mason_2013_Climate_change_adaptation_minerals_industry_professionals.pdf.