Unearthing Environmental and Human Security Risks Critical Minerals in the UK’s Energy Transition

Genevieve Kotarska and Lauren Young
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Critical minerals are broadly defined as minerals that are of vital importance for technology, the economy and national security and are also subject to serious risks relating to the security of their supply. This paper uses the term ‘critical minerals’ broadly, focusing on minerals considered to be of high criticality to the UK in particular. It recognises that this is not a fixed list, and that a country’s specific assessment will affect whether a mineral is considered critical.

A dramatically increased supply of these minerals will be vital for the net zero transition – both in the UK and internationally – and to meet the target to limit global temperature rise to 1.5°C above pre-industrial levels, set at the UN Framework Convention on Climate Change (UNFCCC) Paris Conference in 2015. Yet the extraction of critical minerals poses various environmental and human security risks, many of which pose a threat to the net zero transition, in the UK and globally. This paper explores the environmental and human security risks associated with critical mineral extraction, how rising demand for critical minerals in the context of the net zero transition will impact these risks, and what options exist for the UK to address these risks. It identifies key environmental risks as including the potential for critical mineral extraction to contribute to deforestation, pollution, soil degradation, water scarcity and biodiversity loss. In relation to human security, key risks identified include the potential for critical mineral extraction to contribute to human rights abuses, labour exploitation, crime, conflict and corruption. Where mining takes place on or near Indigenous lands, both environmental and human security risks are found to disproportionately affect already-disenfranchised communities.

While a number of these risks are well established, there is a potential for burgeoning demand for critical minerals to accelerate potential harms. Such harms can occur in situations where rising demand pushes governments to remove or overlook relevant regulations; where new extractive operations open up in countries without mining histories, which lack the infrastructure or capacity to manage the associated risks; where harmful boom–bust cycles of extractive activity occur due to ongoing technological advances; and where a race to secure supplies of critical minerals exacerbates competition and geopolitical tensions.

If the mining sector fails to address these risks as demand booms, public opinion across source and supply countries might turn against the net zero transition as the harms are perceived to outweigh the benefits. It is crucial that the UK leverages its unique position as an international trade, financial and mining hub to help the international community mitigate the risks posed in this regard.
Based on the findings of this research, the authors suggest the following ways forward for consideration by the UK government, many of which are also applicable to other governments in the Global North:

- Use its role as a mining and financial hub to improve regulation, standards and transparency in relation to investment in critical minerals based on key environmental priorities, for example, through the application of the Taskforce on Nature-Related Financial Disclosures, Science-Based Targets for Nature, Global Reporting Initiative and other similar initiatives, thereby supporting integration of high-quality targeted frameworks into this burgeoning sub-sector. This will reward and enhance uptake of best practice by businesses and support regulation in producer countries globally.

- Develop an updated industrial strategy on critical mineral use specifically, to support the strategic acquisition and use of critical minerals and facilitate prioritisation across key industries should a shortage of critical minerals occur. This should be used alongside the UK’s Critical Minerals Strategy to ensure that critical minerals are used strategically, particularly in the face of fluctuations in supply.

- Given the criticality of the net zero transition and the minerals it requires, review domestic policies to maximise recovery of critical minerals that are already in consumer supply chains, in the form of waste. This would broaden opportunities for critical mineral sourcing aside from extraction via new mines. This should include prioritising the upscaling of the UK’s recycling capacity to facilitate the reuse of critical minerals, mindful of the fact that while recycling alone cannot meet demand for critical minerals, estimates suggest that recycling could meet 10% of global demand, while bringing jobs to the UK in support of the ‘levelling up’ agenda.

- Work with manufacturers on extended producer responsibility, right to repair and design-to-recycle best practice to move towards a circular economy and ensure that critical minerals are reused and recycled wherever possible, thereby reducing demand. This will help to reduce wastage of critical minerals and decrease pressure on supply chains.

- Support improved consumer requirements for standards around the production of critical minerals. An example of this can be seen in the case of the 2023 EU Regulation on Deforestation-Free Products, which could be adapted for the critical mineral sector in the UK and more widely across the Global North.

- Support governments in source countries to develop the infrastructure and capability to manage mining-related risks. This could involve providing development assistance to build capacity to apply regulation and best practice, while supporting initiatives that mainstream biodiversity, conservation and social justice into regulation. Such regulation should improve the development and practice of the mining sector in producer countries, in collaboration with
other actors working in this area, such as relevant aid agencies and multilateral development banks.

- Consider how to integrate innovative concepts and proposals that call for a paradigm shift in our approach to economic activity, human wellbeing and the natural world. This can be achieved through an approach which prioritises the pursuit of human and ecological wellbeing over material growth, and has the potential to help us better assess, understand and mitigate the environmental and social harms associated with the mining sector and other sectors dependent on natural resources.
Introduction

The UK, alongside many other countries, has committed to bringing the UK’s greenhouse gas emissions to net zero by 2050. These commitments rely on the transition from an energy sector reliant on fossil fuels to one dominated by net zero or green technologies, particularly renewables. This transition depends on securing reliable supplies of critical minerals.

The route to doing so is far from clear. To meet global decarbonisation commitments, an unprecedented scaling up of critical mineral production is required. According to the International Energy Agency (IEA), by 2040 at least 30 times as much lithium, nickel and other key minerals could be required by the electric car and battery storage industries to meet global climate targets. In terms of rare earth elements (REEs), global demand is expected to expand by 300%–700% by 2040. In this context, demand for many critical minerals is set to outstrip supply, putting net zero targets at risk.

Increasing extraction of critical minerals is therefore key, but is also set to have wide-ranging implications and present an array of environmental and human security risks of its own. Some of these risks are already recognised, while others are on the horizon. Of crucial relevance is the fact that critical mineral extraction is currently highly concentrated in a handful of countries and regions and that some of the key mineral-rich countries are fragile and conflict-affected states, or those with weak state capacity and high levels of corruption. Effective

6. Kang, Milko and Hinnant, “‘The Sacrifice Zone”’. 
7. IEA, ‘Energy Technology Perspectives 2023’, p. 4.
8. Ibid., p. 21.
policies which actively account for these changing dynamics and address these risks are, therefore, crucial.

From the UK perspective, adequately addressing these risks is essential both to mitigating the harms caused and securing sustainable supply chains, and to safeguarding the UK’s reputation on the global stage. The UK government has branded itself as a ‘clean energy superpower’ and, as a global trade and financial hub, is home to some of the most prominent and profitable mining companies, as well as the International Council on Mining and Metals (ICMM), of which the majority of large-scale mining companies are members. The UK is therefore in a unique position to galvanise action on environmental and human security risks relating to critical mineral extraction and to champion a just global energy transition.

This paper examines existing and emergent environmental and human security risks associated with accelerating critical mineral extraction, and the options available to address these risks from a UK perspective. Specifically, this paper addresses three research questions:

1. What environmental and human security risks are associated with critical mineral extraction?
2. How will rising demand for critical minerals in the context of the net zero transition impact these risks?
3. What options exist for the UK to address these risks?

The overarching goal is to identify the key environmental and human security risks associated with the net zero transition and provide decision-makers in the mining sector and policy community with the knowledge they need to anticipate and more effectively mitigate these risks.

It should be noted that there is currently no standard, internationally recognised definition of a critical mineral. Critical minerals are broadly understood as minerals of vital importance for technology, the economy and national security that are also subject to serious risks relating to their security of supply. In the UK, critical minerals are defined according to ‘economic vulnerability and supply risk’, which are caused by ‘combinations of factors including but not limited to rapid demand growth, high concentration of supply chains in particular countries,

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or high levels of price volatility’.\textsuperscript{13} Which minerals are defined as critical differs by country and varies over time.\textsuperscript{14} The UK’s Critical Minerals Strategy, for example, currently defines a cohort of 18 minerals with high criticality for the UK, as well as outlining a ‘watchlist’ of five minerals deemed to be increasing in criticality.\textsuperscript{15} This paper therefore uses the term ‘critical minerals’ broadly, focusing on minerals considered to be of high criticality to the UK in particular. It recognises that there is no fixed list, that minerals considered critical differ according to countries’ specific assessments, and that minerals such as copper and aluminium that are currently not considered critical are also vital for the net zero transition.

**Methodology**

The research for this paper was conducted between May and August 2023 and is based on analysis of primary and secondary data, including a rigorous review of open-source literature, semi-structured interviews with key stakeholders, and the organisation of a virtual validation workshop.

First, the authors conducted a review of the literature to assess existing knowledge of the environmental and human security risks associated with critical mineral extraction. The review covered peer-reviewed academic research, policy briefs, articles and blogs by recognised experts, reports by NGOs, government documents and evaluations. Standard review search strings were used with defined inclusion criteria covering relevance and credibility, with focused searches of Google and Google Scholar conducted using combinations of selected keywords.

Following this, the authors conducted semi-structured interviews with 22 participants from industry associations, government agencies, mining companies, NGOs and other parts of the private sector, as well as investigative journalists and academics, drawing on expert knowledge from a variety of sectors to target gaps identified in the existing literature. Interviewees were based in the UK, the US, Australia, Germany, Denmark, Chile and Sri Lanka, providing international and UK-specific expertise. Interviewees were selected based on their knowledge of the topic, with a snowball sampling method used to identify additional respondents. Questions were tailored to interviewees’ roles, responsibilities and expertise, with the aim of supplementing a lack of detailed published research with first-hand knowledge and experience. All interviews have been anonymised.

\textsuperscript{13} HM Government, ‘Resilience for the Future: The UK’s Critical Minerals Strategy’, 13 March 2023. As per the 2023 UK Critical Minerals Strategy, the following cohort is deemed to be of high criticality for the UK: antimony; bismuth; cobalt; gallium; graphite; indium; lithium; magnesium; niobium; palladium; platinum; rare earth elements; silicon; tantalum; tellurium; tin; tungsten; and vanadium. ‘Watchlist’ minerals are: iridium; manganese; nickel; phosphates; and ruthenium.

\textsuperscript{14} London School of Economics and Grantham Research Institute on Climate Change and the Environment, ‘What are “Critical Minerals” and What is Their Significance for Climate Change Action?’, 30 May 2023.

\textsuperscript{15} HM Government, ‘Resilience for the Future’.
and all data that could lead to the identification of interviewees has been removed. The interview stage formed the foundation of the research, with non-academic literature used to validate and supplement findings from the interviews, where peer-reviewed research was unavailable.

Last, findings were presented and analysed at a virtual workshop held on 15 August 2023, attended by 10 representatives of industry associations, government agencies, NGOs and the private sector, as well as investigative journalists and academics. Written feedback was provided by three additional representatives. The workshop was designed to allow discussion of key findings, as a validation exercise to strengthen the rigour of the research.

Limitations and Scope

The research design has several limitations. The first relates to the inability, within the available timeframe, to provide a detailed analysis of the risks relating to each individual critical mineral. Second, although interviewees were selected for their extensive experience on the topic, a degree of subjectivity is inevitable. This paper recognises that an interviewee’s understanding of the risks is shaped by their specific expertise, potentially leading them to perceive certain risks as more significant than others. Wherever possible, respondents’ views were corroborated by a published source or other respondent data.

The third relates to the emerging nature of many of the risks identified, meaning there is limited peer-reviewed research available. Non-academic literature was used to validate and supplement findings from the interviews, where peer-reviewed research was unavailable. Equally, given that primary research for this paper comprises a limited number of semi-structured interviews, the findings can only be viewed as preliminary, with further research needed in the immediate future.

Finally, this research focuses specifically on the risks relating to critical mineral extraction. The authors acknowledge that critical mineral processing and Chinese dominance in this area is an important part of the wider discussion on securing net zero supply chains, but examining this is beyond the scope of this paper.

Structure

Analysis of the findings is organised into three chapters. Chapter I provides a brief overview of existing and clearly recognised environmental and human security risks associated with critical mineral extraction. Chapter II builds on this to explore how changing patterns of demand triggered by the net zero
transition are set to impact these risks. Chapter III considers the options available to address these risks from a UK perspective. The conclusion draws together the findings and presents a series of recommendations.
I. Existing Risks Linked to Critical Mineral Extraction

The environmental and human security risks linked to critical mineral extraction are not unique in and of themselves, with many associated with wider mining activities. Yet with exponential growth in demand for minerals for the net zero transition and the expected acceleration in critical mineral mining activities, these risks stand to intensify. This chapter provides a brief overview of existing, acknowledged risks linked to critical mineral extraction, which will serve as a foundation for subsequent chapters.

Environmental Risks

Critical mineral reserves are often located in remote, high-integrity, biodiversity-rich locations (see Figure 1), with their extraction posing direct risks to the environment. Many of these harms occur at the mine site itself, both through mineral extraction and the development of the required infrastructure to support it. Mining requires land use change, frequently resulting in deforestation and biodiversity loss. Around 1,600 mining operations are in key biodiversity areas and a further 2,000 in protected areas. In the context of critical minerals, 80% of cobalt and 54% of nickel are sourced from areas where biodiversity is at risk. The infrastructure required to support mining activities also presents environmental challenges. Crucially, the construction and maintenance of roads, ports, railway tracks and power lines can impact the wider landscape, often leading to further deforestation and habitat fragmentation. With the growth in demand for critical minerals, these risks could escalate in key locations.

19. Ibid., p. 137.
Figure 1: Selected Countries and Harms Associated with Mineral Mining for the Net Zero Transition

Source: Map adapted by the authors from Nat Lowrey, ‘A Material Transition: Exploring Supply and
Sub-Saharan Africa has some of the world's largest deposits of minerals essential to the net zero transition, including cobalt, graphite, lithium, nickel and REEs. An expanding rate of extraction of these minerals could exacerbate existing environmental problems. According to the UN Food and Agriculture Organization, from 2010–20, the African continent witnessed the greatest annual rate of net forest loss of any region in the world. While some of this is attributed to agriculture and commercial logging, mining also played a key role; a 2022 study showed that mining was a significant direct driver of deforestation in Ghana and an indirect driver of deforestation in Gabon and Zambia. Given that Africa is home to significant reserves of manganese, platinum, cobalt and graphite, increased mining activity for critical minerals risks exacerbating deforestation in the region.

Similar risks have been highlighted in other regions. In a prominent example, Indonesia has seen rapid expansion in mining activity targeting nickel and cobalt, which are commonly extracted together. This is negatively impacting both inland tropical forests and coastal mangrove forests – causing particular damage, in view of their high carbon storage capacities. Similar concerns have been raised in relation to critical mineral extraction in the Pacific Islands and Latin America. However, it is important to put these risks into a wider perspective. With any change of land use comes a degree of habitat degradation,
with mines currently occupying just 1% of Earth’s land surface, whereas agriculture accounts for 38%.\textsuperscript{29}

However, environmental risks linked to critical mineral and indeed all forms of mining go beyond those related to the direct footprint of a mine site itself. Risks relating to air, water and other forms of pollution are present in all stages of mine development, from pre-feasibility and feasibility to construction, operation, maintenance and closure of any mine. These risks apply in the extraction of critical minerals just as in the extraction of other major metals not currently deemed critical, such as gold, iron ore and copper. Separating the valuable fraction of mined material results in potentially hazardous waste. This includes waste rock, comprising the rocks removed to access the target mineral, and tailings, which are fine-grained waste from the crushing and processing of an ore.\textsuperscript{30} Such waste often contains dangerous levels of heavy metals, chemicals and radioactive components, and risks contaminating the local environment during storage or disposal.\textsuperscript{31} Other waste materials generated during the extraction process – for example, acidic waste water during lithium extraction (see Box 1) – also present a risk. Here, it is important to emphasise that the risk of pollution extends beyond the lifecycle of the mine, after closure. Mine abandonment, decommission and repurposing also create risks from the release of contaminants into the environment.\textsuperscript{32} Indirect environmental risks linked to critical mineral mining also derive from the water-intensive nature of much of this activity, which can lead to water shortages and water table depletion, threatening both species and habitats (see Box 1).

Finally, the power used in extracting critical minerals itself contributes to global carbon emissions, although carbon emitted at the extraction stage of the supply chain is likely to be significantly lower than that emitted during the processing stages.\textsuperscript{33} Innovation is taking place in this area, with a fully electric mine in

\begin{footnotesize}
\begin{enumerate}
\item Haddaway, Lotfi and Mbuagbaw, ‘Evidence of the Impacts of Metal Mining and the Effectiveness of Mining Mitigation Measures on Social–Ecological Systems in Arctic and Boreal Regions’.
\end{enumerate}
\end{footnotesize}
operation in Canada\textsuperscript{34} and mining companies investing in renewable power to support remote sites.\textsuperscript{35}

Understanding these existing environmental risks is vital as critical mineral extraction accelerates to meet global decarbonisation commitments. As explored in Chapter II, the dynamics and context surrounding such extraction activity are likely to change as fluctuating demand for specific minerals reshapess and intensifies many of the risks we face today.

**Human Rights Abuses**

Human security risks associated with the extractive industry are also well established.\textsuperscript{36} In the context of critical minerals, these risks are clearly seen in cases such as artisanal cobalt mining in the Democratic Republic of the Congo (DRC) – a country holding 75\% of the world’s currently identified cobalt reserves, 15–20\% of which is estimated to be mined artisanally.\textsuperscript{37} Here, artisanal cobalt miners face the threat of being beaten, tortured or killed by state and private security services.\textsuperscript{38} Poor working conditions present further risks, where artisanal miners work with no or insufficient personal protective equipment, ventilation or healthcare.\textsuperscript{39} Child labour is also a concern. Estimates of the number of children working in the DRC’s cobalt sector range from 4,500 to 40,000, some of whom are as young as six.\textsuperscript{40} Such child labour ranges from children helping their parents at weekends to those working as indentured servants.\textsuperscript{41} Despite attempts to formalise artisanal mining in the DRC, a range of studies highlight the limitations of bureaucratic formalisation in countries such as the DRC, where

\begin{itemize}
\item \textsuperscript{37} Siyamend Al Barazi et al., ‘Cobalt from the DR Congo – Potential Risks and Significance for the Global Cobalt Market’, English translation, Commodity TopNews v.53, 2017, p. 8. Artisanal mining, sometimes referred to as small-scale mining, is an informal economic sector which sees workers use basic tools to extract resources. It is an important source of income for many rural communities around the world.
\item \textsuperscript{38} Author interview with representative from academia, London, June 2023; Benjamin Sovacool, ‘When Subterranean Slavery Supports Sustainability Transitions? Power, Patriarchy and Child Labor in Artisanal Congolese Cobalt Mining’, Extractive Industries and Society (Vol. 8, No. 1, March 2021).
\item \textsuperscript{39} Author interview with representative from academia, London, June 2023; Sovacool, ‘When Subterranean Slavery Supports Sustainability Transitions?’.
\item \textsuperscript{40} Sovacool, ‘When Subterranean Slavery Supports Sustainability Transitions?’, pp. 283–85.
\item \textsuperscript{41} Kevin Bales and Benjamin K Sovacool, ‘From Forests to Factories: How Modern Slavery Deepens the Crisis of Climate Change’, Energy Research & Social Science (Vol. 77, July 2021), p. 6; author interview with representative from academia, London, June 2023.
\end{itemize}
miners may lack the ‘resources and skills to participate effectively’ in these processes.42

Beyond the DRC, child labour is reported in numerous other critical mineral extraction operations (see Figure 1), including tantalum supply chains in Mozambique, Burundi and Rwanda.43 Nickel mining in Guatemala has been linked to cases of murder, sexual violence and forced displacement,44 while mining for REEs in Myanmar has also been associated with wide-ranging human rights abuses.45 Abuses are commonly targeted at artisanal miners, labourers and local communities, provoking local-level conflict and community resistance, with resistance at times interrupting critical mineral mining operations’ ability to operate effectively.46

Further cases of weak enforcement of labour rights in relation to critical mineral mining can be seen in artisanal mining of cobalt and tin, as well as in the mining and processing of nickel.47 Such risks may be exacerbated as mining moves to previously untapped regions rich in critical minerals, particularly those with a track record of human and labour rights abuses. Saudi Arabia, for example, has untapped critical mineral reserves worth about $1.3 trillion, but a very poor track record in relation to human and labour rights.48 In January 2023, the UK announced its intention to deepen collaboration on critical minerals with Saudi Arabia, as part of its ‘plan to build partnerships around these vital resources across the world’.49 Human rights standards must be a key consideration in any future collaboration, and such partnerships are an opportunity for the UK to


49. HM Government, ‘UK and Saudi Arabia Pledge to Deliver Close Cooperation on Critical Minerals’.
engage bilaterally and use its diplomatic and financial position to ensure human rights standards are upheld in critical mineral supply chains.

As in the case of environmental risks, concerns relating to human rights and labour abuses in the critical minerals sector are not necessarily fundamentally different from those linked to the wider mining sector. However, contextual vulnerabilities – particularly in light of the high demand driving increased mining for critical minerals in areas with weak governance and/or no history of mineral extraction – could raise the risk of human rights abuses and exploitation, as discussed further in Chapter II.50

Corruption, Crime and Conflict

Corruption in the extractive sector is widespread. In 2016, the OECD claimed that one in five cases of transnational bribery were linked to the extractive sector.51 High-profile cases involving mining and commodities giants such as Glencore illustrate the extent of the issue; in November 2022, for example, Glencore was ordered to pay £281 million in penalties after a Serious Fraud Office investigation revealed it had paid $29 million in bribes for preferential access to oil in Cameroon, Equatorial Guinea, Ivory Coast, Nigeria and South Sudan.52 Meanwhile, in Nigeria alone, an estimated $400 billion in oil revenues has been lost to corruption since 1960.53

Similar trends are emerging in relation to critical minerals. In June 2022, court auditors in the DRC pointed to over $400 million in missing tax advances and loans that state mining company Gecamines said it had paid to the national treasury.54 Gecamines holds minority stakes in several of the world’s largest copper and cobalt projects, both of which are key minerals for the net zero transition.

In this context, a range of NGOs have raised the alarm over vulnerabilities to corruption in relation to critical mineral extraction specifically, and the potential for this to derail the energy transition.55 Key concerns here relate to the location of most current critical mineral reserves in a small number of developing and

52. Serious Fraud Office, ‘Glencore to Pay £280 Million for “Highly Corrosive” and “Endemic” Corruption’, 3 November 2022.
middle-income states, many characterised by weak governance, high levels of corruption and legacies of fragility and conflict.\textsuperscript{56} Here, recent research has flagged the risk of clean energy minerals being used for trade-based money laundering, and the risk that close links between politically exposed persons and commodity trading more broadly could implicate supply chains themselves in conflict finance.\textsuperscript{57} Meanwhile, artisanal and small-scale miners are flagged as potentially suffering high levels of exposure, particularly in cross-border mining hotspots. As noted in a 2022 report by Maha Rafi Atal, Stephanie Trapnell and Dieter Zinnbauer, ‘given the race for newer and more efficient clean energy technologies, there is an ongoing risk that weakly regulated mining is exploited for illicit profit, which may involve not only corruption, but also human trafficking and human rights abuses’.\textsuperscript{58}

Efforts to tackle corruption must be central to discussions on supply chains, as critical mineral extraction presents a key revenue-generating opportunity for many states, with critical minerals comprising between 4\% and 7\% of mining revenue.\textsuperscript{59} As Liesbet Gregoir and Karel van Acker remind us, corruption, tax avoidance and government effectiveness ‘influence the potential of benefits returning to local communities’,\textsuperscript{60} which can in itself impact community support for mining projects, undermining supply chain security. Given the need to trade with these mineral-rich countries to achieve net zero, tackling corruption in critical mineral supply chains is crucial.

Wider links to criminality and conflict traverse extractive industries and are well documented in relation to gold and diamond mining, but they also play out in the context of critical minerals. Organised criminal activity around the supply and trafficking of REEs has been reported in China, with authorities seizing multi-tonne consignments of REEs worth millions of dollars that were being illegally smuggled out of the country.\textsuperscript{61} In 2022, an AP investigation flagged the role of military-linked militias in human rights abuses linked to REE mining in Myanmar, with militias enforcing control in key areas and demanding a cut of the profits generated.\textsuperscript{62} Critical mineral-linked criminality is also prevalent in other regions; in 2022, a Chinese national was jailed in Nigeria after attempting to smuggle 25 tonnes of lithium-containing lepidolite out of the country.\textsuperscript{63} Lithium

\begin{thebibliography}{9}
\bibitem{56} Maha Rafi Atal, Stephanie Trapnell and Dieter Zinnbauer, ‘Merchants of Integrity: Commodity Trading and Corruption Research for a World in Transition’, Global Integrity, 17 October 2022.
\bibitem{57} Ibid.
\bibitem{58} Ibid.
\bibitem{60} Ibid.
\bibitem{61} Hunter and Ofosu-Peasah, ‘Organised Crime Threatens Green Minerals’.
\bibitem{62} Kang, Milko and Hinnant, “The Sacrifice Zone”.
\end{thebibliography}
deposits in Mexico have similarly been reported to be at risk of criminal exploitation.\textsuperscript{64} Intersecting with critical human rights risks, this activity often leaves local communities at the mercy of profit-chasing criminal groups, enhancing their vulnerability to violence, displacement, extortion and labour exploitation.\textsuperscript{65}

These points relate closely to risks around conflict financing. Just as gold, diamonds and gemstones are known to have been used to fund armed groups in key source countries globally, critical minerals are similarly associated with such activity.\textsuperscript{66} In Africa’s Great Lakes region, prominently, 3T mining (tin, tungsten and tantalum) has been linked to the operations of non-state armed groups and conflict financing, prompting the passage of associated conflict minerals legislation, including the EU’s 2021 Conflict Minerals Regulation.\textsuperscript{67} Here, interviewees expressed concern that the critical minerals boom could trigger new forms of localised conflict, especially in the case of extraction via artisanal and small-scale mining.\textsuperscript{68}

On this point, it is important to note that critical minerals are generally less transportable than gold or diamonds and must be moved at much higher volumes to generate profits, limiting the appeal for many localised armed groups and criminal actors. Despite this, interviewees expressed concern about the risk of local-level conflict and criminal extortion.\textsuperscript{69} Meanwhile, the potential for critical minerals to support improved infrastructure and supplement existing revenues in supply countries is unlikely to mitigate in full the potential emergence of a new ‘resource curse’, unless more is done to address the human and environmental security risks highlighted in this paper, the impacts of which are felt most keenly at a local level.\textsuperscript{70} Indeed, localised tensions are known to be exacerbated by

\begin{itemize}
\item \textsuperscript{64} Hunter and Ofose-Peasah, ‘Organised Crime Threatens Green Minerals’; author interview with representative from industry, London, July 2023.
\item \textsuperscript{65} Kang, Milko and Hinnant, ‘The Sacrifice Zone’.
\item \textsuperscript{69} Author interview with representative from industry, London, July 2023.
\end{itemize}
encroachment on community territory, human rights violations and environmental degradation associated with critical mineral mining, as seen in relation to lithium mining in Chile and nickel mining in Indonesia.71

These corruption, crime and conflict risks are likely to be exacerbated in the context of burgeoning demand for critical minerals and in the global rush to secure supply chains. With mineral-rich countries and mining companies looking to capitalise, this could serve to both deepen the impact of existing human and environmental security risks and jeopardise the transition to net zero as community resistance, local-level conflict and criminality impact the ability of mining companies to operate, undermining reliable supplies.72 Opportunities to mitigate these risks are discussed further in Chapter III.

Indigenous Rights

As indicated above, the brunt of many environmental and human security risks related to critical mineral extraction is borne by local communities. Indigenous communities are known to be particularly impacted: a recent study found that 54% of critical mineral mining projects are located on or near Indigenous land.73 In many cases, this puts Indigenous communities on the frontline of the effects of critical mineral extraction.74 While consultation is required, the standard of consent is not yet industry standard, with the ICMM specifying that members should ‘work towards obtaining consent of Indigenous Peoples’ rather than requiring that they obtain it.75 Where resistance occurs, Indigenous Peoples


73. John R Owen et al., ‘Energy Transition Minerals and their Intersection with Land-Connected Peoples’, Nature Sustainability (Vol. 6, February 2023), p. 204. This study included formally Indigenous-controlled territories and Indigenous Peoples’ lands where collective rights could be asserted, but where state recognition may be absent.

74. Ibid.

have been subject to abuses including forced displacement, sexual violence, torture and murder.\textsuperscript{76} Mining has also been linked to the murder of land and environmental rights defenders in countries such as the Philippines, Mexico, Venezuela, Nicaragua and Ecuador.\textsuperscript{77}

Even when not directly subject to abuse, Indigenous Peoples face indirect harms. Deforestation for nickel mining in Indonesia risks destroying the way of life of the nomadic O Hongana Manyawa tribe; water depletion from lithium mining in Chile continues to impact Indigenous ways of life; and nickel mining in Guatemala has destroyed natural resources vital to the livelihoods of many Indigenous Peoples.\textsuperscript{78} These are just a few examples of how critical mineral extraction is impacting Indigenous communities. With an absence of standards to ensure that Indigenous communities both consent to and benefit from mining activities, both Indigenous rights and land could be sacrificed in the name of the net zero transition. This outcome can be avoided if the risks identified here are properly addressed. Some possible ways forward are outlined in Chapter III.


Box 1: The Lithium Triangle, Water Scarcity and Biodiversity Loss

Lithium is a key component in lithium-ion batteries and is widely used in the batteries that power electric vehicles, smart devices, renewable power plants and other key technologies. With net zero targets fuelling skyrocketing demand for lithium, this demand is being met by a surge in extraction in countries such as Chile – the world’s second-largest lithium producer.79

The ‘Lithium Triangle’ on the borders of Chile, Argentina and Bolivia, for example, is a region rich in lithium deposits. Within this, roughly a quarter of deposits lie beneath the Salar de Atacama salt flats in northern Chile. Often known as the Atacama Desert, this is one of the driest places on earth, with average annual precipitation of 1 mm. Access to water is limited, with available sources vital for local communities and their livelihoods, as well as local flora and fauna. Yet the mining of lithium in this region is increasingly serving to consume, contaminate and divert the scarce water resources available.

Estimates suggest up to two million litres of saline groundwater (commonly known as brine) are needed to produce one tonne of lithium,80 with brine extraction the dominant method used – in which brine is extracted, concentrated in large evaporation pools and treated with sodium carbonate. Brine typically has a salt content higher than seawater and is therefore regulated separately from water. Brine is neither potable nor suitable for agricultural use.81 Beatriz Bustos-Gallardo, Gavin Bridge and Manuel Prieto note that ‘this distinction allows firms to frame brine pumping as an action independent from freshwater extraction, and claim it has no effect on the hydrogeological or ecological balance of the basin’.82 Yet research indicates that increased groundwater extraction for the lithium industry has contributed to water deficit in the Salar de Atacama, with the amount of water pumped out of the region increasing by 21% between 2000 and 2015.83

Concerns over the lithium industry’s contribution to water scarcity in the region have exacerbated tensions across local communities already facing the fallout from scarce rainfall and high rates of evaporation due to climate change.84 Meanwhile, key water sources that remain available for humans,

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80. Mie Obbekær, ‘How Much Water is Used to Make the World’s Batteries?’, DanWatch (December 2019).
livestock and crop irrigation have been contaminated by waste products of lithium extraction operations. In this context, many communities now rely on tankers delivering water. And while this situation has been triggered by expanding electric vehicle production at a global level, electric vehicles remain a rarity in Chile itself, highlighting the unequal distribution of harms and benefits in relation to critical minerals.\(^85\)

Beyond these human impacts, lithium extraction is contributing to damage to the Atacama Desert’s unique biodiversity. The Laguna Santa Rosa Wetland, for example, is shrinking as a result of water scarcity, threatening the area’s 53 endemic species, 17 of which are classified as endangered.\(^86\) Other vulnerable species are also disappearing from the Atacama region, which is experiencing a significant reduction in plant cover, specifically algarrobo trees.\(^87\) Meanwhile, evaporation pools used in the extraction process are highly damaging to many bird species – flamingos in particular are misled by the large bodies of contaminated water.\(^88\)

To meet global demand for lithium, the companies already operating in the Atacama salt flats have increased their activities, while companies not yet present are also showing interest in the region’s reserves. Chile is, however, in the process of reassessing its relationship with the environment. A new constitution that could have significantly affected the country’s extractive industries was rejected in a referendum in 2022. However, efforts to rewrite the constitution continue, with hopes among some that a new constitution will be accepted this year, which could have consequences for how extractive industries are able to operate in the country.\(^89\)


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85. Greenfield, ‘Lithium Mining Is Leaving Chile’s Indigenous Communities High and Dry (Literally)’.
II. Elevated Demand and Rising Risks

As highlighted in Chapter I, some of the key human and environmental security risks relating to critical mineral extraction align closely with those associated with the extractives sector at large. However, the forecasted boom in demand presents particular risks – many of which are under-acknowledged and understudied, and which will require specific mitigations.

Indeed, as countries accelerate efforts to reach net zero, a massive uplift in critical mineral mining will be required to meet skyrocketing demand. Critical mineral demand for the production of electric vehicles, for example, is expected to increase almost 300 times between 2020 and 2050, to meet the IEA net zero scenario.90

In recognition of this, key consumer countries have been working to refine their strategic approach to securing critical mineral supply chains. These efforts can be seen in the US Critical Materials Strategy, the UK’s Critical Minerals Strategy and the EU’s Critical Raw Materials Act, among others.91 However, few of these strategies adequately account for the particular environmental and human security risks likely to be presented as critical mineral extraction is scaled up.

Nor has there been extensive research focused on the emergent risks across source countries in the face of unprecedented global demand. This chapter draws on both the limited existing literature and data from semi-structured interviews to harness current cross-sectoral knowledge on what can be anticipated in this regard.

Fast-Tracking and Corner-Cutting

Interviewees flagged that corner-cutting in the process of authorising mine permits is a key issue. This issue is especially acute given unprecedented demand – and the resulting competition likely to be created between countries seeking rapidly to secure supplies. Where such corner-cutting takes place, this will likely


see an erosion of processes designed to limit the damage done by mining, including community engagement, the securing of prior informed consent that is given freely, and the undertaking of comprehensive social and environmental impact assessments.\textsuperscript{92}

Currently, it takes between 10 and 20 years, depending on the context, to undertake the relevant assessments and obtain approvals required for a new mine. However, given the need for the energy transition to occur at speed, there is incentive for governments and companies to accelerate the process, which may motivate corner-cutting.\textsuperscript{93} The incentives to cut corners are likely to be higher in countries with high levels of corruption and low levels of government capacity, where the mine development process will be subject to lower levels of regulatory oversight.\textsuperscript{94} At a local level, corner-cutting is highly likely to exacerbate the human and environmental security risks outlined above, with local communities forced to absorb potential negative impacts resulting from time pressures on the energy transition.\textsuperscript{95}

In some contexts, these pressures – combined with burgeoning critical mineral demand – may also motivate governments to remove some of the ‘red tape’ that provides important protections for the environment, communities and workers, to increase production and attract investment.\textsuperscript{96} Such fast-tracking is already taking place, with incentives provided and regulatory requirements relaxed in countries such as the US, Australia, Brazil, Peru, the Philippines and South Africa.\textsuperscript{97}

In the US, for example, the Thacker Pass lithium mine in Nevada is one of a number of critical mineral mines fast-tracked through approval processes in light of the ‘strategic’ value of the support provided both to economic recovery and the expanding lithium-ion battery market.\textsuperscript{98} Its development has occurred despite the objections of Native American tribes, who claimed that they had not

\textsuperscript{95} Owen et al., ‘Fast Track to Failure?’, p. 8.
\textsuperscript{96} Ibid., pp. 3–4.
\textsuperscript{97} Ibid.
\textsuperscript{98} Ibid., p. 4.
been properly consulted during the approval process, and who went on to launch legal action to challenge the mine’s approval.\textsuperscript{99}

In Indonesia, the government’s efforts to increase foreign investment – including in nickel mining and processing – have had stark consequences. Specifically, in 2022, after more than two years of constitutional and legal challenges, the government of Joko Widodo passed the controversial Omnibus Law, revising over 70 existing laws, with the aim of removing red tape, improving the investment climate and creating jobs. The law has been extensively criticised for weakening protection for workers and the environment; of specific interest for this paper is the law’s requirement that only investments considered high risk must conduct an environmental impact study, replacing wider requirements under previous legislation.\textsuperscript{100}

The move is likely to exacerbate existing environmental and human security issues relating to critical minerals. While Indonesian nickel production doubled between 2020 and 2022 and has continued to rise since, numerous cases have been reported of workers losing their lives and suffering serious health conditions, with thousands of hectares of rainforest destroyed and water and land polluted, at great cost to local communities and Indigenous populations.\textsuperscript{101} The Indonesian case highlights some of the risks associated with the critical mineral boom, with such dynamics likely to play out in many more cases as demand continues to increase. Ultimately, there is a risk of fast-tracking mines, cutting regulatory corners and removing red tape occurring at the cost of workers, local communities and the environment.

### Exploring New Mineral-Rich Regions

Many of these concerns surrounding fast-tracking and corner-cutting are likely to be exacerbated in regions with unexplored critical mineral reserves, particularly in locations with no history of mineral mining. Such areas without previous experience of mining activity are likely to have lower levels of infrastructure, human population and activity in general, and are likely to have higher ecological integrity. Once a given mineral becomes more valuable, a higher incentive to build key infrastructure to extract that mineral is likely to have a significant impact on previously intact ecosystems.

Meanwhile, in these locations, the minimal presence of industry to date is likely to be matched with underdeveloped governance and regulatory frameworks for

\textsuperscript{99} Ibid., p. 4.
\textsuperscript{100} Reuters, ‘Explainer: What’s at Stake with Indonesia’s Controversial Jobs Creation Law?’, 9 June 2022.
\textsuperscript{101} Yeung, ‘Workers Are Dying in the EV Industry’s “Tainted” City’; Brook, “They Will Die”.
mining activity. In the absence of mandatory social and environmental impact assessments, requirements to undertake community engagement or seek a social licence to operate, the likelihood of environmental and human security risks occurring rises. Increasing global demand for critical minerals intensifies these concerns, incentivising fast-paced mineral exploration and the identification of new reserves in countries without histories of large-scale mining or in areas beyond national jurisdiction (see Box 2).

In 2012, for example, discoveries of mineral deposits in Malawi – a country with minimal prior history of mining – made it Africa’s largest source of REEs at that time. Those discoveries then mandated a rapid updating of the country’s Mining Act, a need to establish wider legal and institutional frameworks and, in the words of the then Minister of Natural Resources, Energy and Environment Cassim Chilumpha, a ‘crash program to train mining engineers, legal experts in mining and other related fields in the sector’. With many of the mines recently becoming operational, the contribution of mining to Malawi’s GDP is projected to increase from 1% to 6% by the end of 2023. Yet during the exploration phase and establishment of the mines and related infrastructure, the government has faced criticism for forcibly evicting villagers from their homes and for risking food and water security. Corruption has meant that Malawi has struggled to effectively address these issues, resulting in a situation where some local communities have denounced the mining sector and the lack of consultation, amid warnings that the country’s mining boom ‘will not necessarily translate into benefits for affected communities’.

102. Author interviews with representatives from NGOs, academia and industry, London, July 2023.
103. An industry’s ‘social licence’ to operate is the level of approval or acceptance it has from society to operate.
104. Author interviews with representatives from NGOs, academia and industry, London, July 2023.
105. The Kayereke uranium mine – Malawi’s first large-scale mining project – opened in 2009, preceding an ‘unprecedented increase in the number of foreign companies looking to invest in the mining sector’. For more information, see Paul Justice Kamlongera, ‘The Mining Boom in Malawi: Implications for Community Development’, Community Development Journal (Vol. 48, No. 3, July 2013).
107. Ibid.
Concerns surrounding the Malawian experience extend to other countries in Africa, with low levels of exploration meaning that the full potential of the continent’s REEs reserves remains undetermined. As in the case of Malawi, there is concern over the initiation of potential extraction activities – of REEs and other critical minerals – in countries with high levels of corruption, weak governance and limited state capacity, where environmental protections and labour rights are likely to be weak or poorly enforced. Similar concern has been raised over the Middle East’s vast, undeveloped critical mineral resources, and the poor environmental and human rights record of many countries in that region. In locations with limited infrastructure, meanwhile, interviewees flagged further risks associated with the rapid development of infrastructure in new mining regions, noting the potential to facilitate the incursion of new licit and illicit industries, triggering further potential social and environmental harms.

**Boom and Bust**

Beyond those risks attributed to sudden mining booms in newly identified critical mineral-rich regions, there is growing concern around the implications of boom–bust cycles arising from the net zero transition. In the face of a sustained drive to advance green technologies and reduce the demand these exert on critical mineral supplies, future technological innovations and circular economies could rapidly and unexpectedly reduce demand for certain minerals.

Beyond the inevitable disruption caused by a rapid scaling up and down of demand, interviewees emphasised the potential consequences in contexts where there is a lack of experience in properly closing mines at both the government and industry levels, with sudden, poorly managed mine closures presenting a range of environmental and human security risks. At the environmental level, storage of tailings (the waste products of mining and mineral processing) requires

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113. Author interviews with representatives from industry, academia and NGOs, London, July 2023.


116. Author interviews with representatives from NGOs, academia and industry, London, July 2023.


management long after a mine has ceased operating and, if not managed correctly, can have devastating environmental consequences. The 2015 Samarco Dam failure demonstrated the potential impact of the failure of tailings disposal dams. The incident resulted in a ‘tidal wave’ of mining waste washing across the Brazilian landscape in what is considered Brazil’s worst environmental disaster.\(^{119}\) Although relating to iron ore – rather than critical minerals – the case illustrates the potential dangers arising should extraction activities unexpectedly wind down and tailings storage be mismanaged. Meanwhile, the adequate rehabilitation of mine sites, including reversal of the land use change that occurs with the establishment of a mine, is also a concern in the case of rapid boom–bust cycles.\(^{120}\) There are few examples globally of mine sites having been appropriately rehabilitated.\(^{121}\) That said, the majority of modern large-scale mines remain in operation, and mining companies increasingly have to provide financial assurance for mine rehabilitation to prevent mines being abandoned in the case of bankruptcy or similar events.\(^{122}\)

At the human security level, beyond the health risks associated with scenarios such as those outlined above, there is also the question of social rehabilitation.\(^{123}\) Mining companies’ social licence to operate often rests on the benefits that mining activities purport to bring to local communities in the form of revenue and improved infrastructure. Historically, in a range of cases, closures of mines have led to communities abandoning settlements, leaving ‘ghost towns’ in their wake. Although there are few examples relating to critical minerals specifically, the collapse of the diamond mining industry in the town of Kolmanskop in Namibia and the closure of platinum mining in Atok, Limpopo in South Africa are two wider examples.\(^{124}\)


\(^{120}\) Author interviews with representatives from NGOs, academia and industry, London, July 2023.


Increasing Geopolitical Competition

Many of the aforementioned issues risk exacerbating the geopolitical tensions associated with the critical minerals boom. Indeed, some commentators have warned of the potential for critical minerals to spark a ‘new arms race’ or a ‘new Cold War’, especially given the role of the defence sector in driving critical mineral demand and, notably, the US decision to use wartime powers to secure critical mineral supply chains. The 1950 Defense Production Act gives the US president the power to ‘shape national defense preparedness programs and to take appropriate steps to maintain and enhance the domestic industrial base’. The act was expanded in 2022 by President Joe Biden to support production of net zero technologies, and again in 2023 to facilitate funding for projects related to the production of minerals such as lithium, REEs and tantalum.

Competition over critical minerals could also exacerbate tensions between great powers in the context of China’s dominant role in a range of critical mineral supply chains. While China’s dominance in the context of critical mineral processing is outside the scope of this paper, it is important to note that China also has significant critical mineral reserves, which are subject to the same risks as those highlighted in this paper. China is the largest importer of lithium, nickel, cobalt and manganese, has significant reserves of lead, selenium, tellurium, tin, zinc, graphite, lithium and titanium, and dominates lithium battery production. The country also dominates REE supply chains, accounting for 70% of global rare earth ore extraction and 90% of rare earth ore processing, following decades of state investment, export controls, cheap labour and low environmental standards.

In this context, the US and its allies are increasingly looking to secure their own supplies to minimise potential supply chain vulnerabilities. Meanwhile, an international environment characterised by growing contestation over critical

minerals, among other factors, could see mineral-rich source countries rendered increasingly vulnerable to great power meddling. Such a scenario – whether real or imagined – has already played out in Bolivia in 2019, when former president Evo Morales accused the US of orchestrating a coup to ensure access to Bolivia’s lithium reserves. Investigative journalism website *Declassified* has made similar allegations against the UK.

Yet the likelihood of intensified great power competition over critical minerals is debated. Some commentators cite critical minerals’ relative abundance and recyclability, and the fact that, unlike with oil and gas, a break in constant supply is unlikely to spark immediate crisis. In this context, critical mineral competition is arguably unlikely, alone, to act as an impetus for all-out war. However, this does not rule out intensified competition, tension and violence at the local level – a scenario potentially amplified by the unequal burden of critical mineral demand from the Global North and countries such as China on source countries in the Global South, and the resultant environmental and social impacts on communities largely concentrated there.

In this context of geopolitical competition it is important to note that the UK’s position has been weakened since leaving the EU. UK allies – such as the US and EU – are competing with both hostile states and allied states for access to critical minerals. The UK may struggle to leverage negotiating power following withdrawal from the EU and more work is needed to establish how the UK will address these geopolitical concerns.

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Box 2: Deep-Sea Mining Case Study

Over millennia, deposits of critical minerals such as manganese, nickel and cobalt have built up in nodules on the ocean floor, thousands of metres below sea level.\(^{141}\) Deep-sea mining, proponents argue, is a means of sourcing critical minerals ‘responsibly, ethically, and with a minimal emissions load on the planet’, reducing the need for land-based mining and enabling countries such as the US to decrease their dependence on imported minerals.\(^{142}\) However, others caution that deep-sea mining may risk the destruction of deep-sea ecosystems (of which we have little understanding), and cause widespread pollution, the decimation of fish stocks and the disruption of deep-sea carbon storage.\(^{143}\) The lack of scientific data on the harms and benefits has prompted several countries to call for a moratorium on deep-sea mining.\(^ {144}\)

Crucially, deep-sea mining would largely take place in international waters, raising crucial legislative and regulatory questions. While the International Seabed Authority (ISA) will ultimately decide whether deep-sea mining goes ahead, decision-making has been delayed until 2025 after Costa Rica, Chile and France insisted that no permits be granted until a stronger regulatory landscape had been established. In the meantime, the ISA has issued contracts for exploratory work; as of November 2022, China held five of the 30 contracts issued.\(^{145}\)

Should such activity go ahead, this ‘new potential extractive frontier’ could have major geopolitical ramifications.\(^ {146}\) China appears to be leading the race: as well as holding the greatest number of deep-sea mining exploration contracts, it has made funding for research in this area a national security and economic priority. Other issues arise from the fact that the US is not an ISA member state and is currently engaged in drafting parallel legislation. As well as limiting the US’s ability to influence global policy on deep-sea mining, this position also potentially disincentivises other countries to comply with the ISA.\(^{147}\)

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Deep-sea mining in international waters throws up other issues of relevance, at times involving overlaps with other key areas, such as fisheries. Norway, for example, plans to deep-sea mine an area the size of Germany on its continental shelf, most of which lies outside Norway’s exclusive economic zone, potentially infringing UK fishing rights.\textsuperscript{148} Key parts of the seafood industry have called for a pause in deep-sea mining plans, as recent research has established that tropical tuna fishing grounds in the Pacific are likely to overlap with areas licensed for deep-sea mining.\textsuperscript{149} This, in turn, could impact coastal communities reliant on fishing, resulting in loss of livelihoods and community displacement, among other harmful impacts.\textsuperscript{150}

More broadly, fundamental questions relevant to the ISA’s 2025 decision remain unanswered. As yet, the consequences of deep-sea mining of critical minerals for marine biodiversity and ecosystems are unquantified, while responsibility and payment of any compensation is yet to be determined. Additionally, as with much terrestrial mining, the equitable sharing of the benefits of such mining in international waters is far from guaranteed.

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\item 150. Greenpeace, ‘Deep-Sea Mining’.
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III. The Road Ahead

With the world’s attention on the net zero transition and with critical minerals playing a pivotal role in this transition, the international community – and the UK as a key financial and mining hub – has a unique opportunity to address the environmental and human security risks arising. As many of the risks identified are not unique to critical mineral mining, there are already a range of known options available. However, the rapid acceleration of critical mineral extraction could intensify existing challenges, necessitating a fundamental rethink of how to apply interventions and embrace emerging options in this space. This chapter uses both the limited available literature on this topic and data drawn from semi-structured interviews designed to gather insights from across a range of sectors, to consider the options available.

A Governance Rethink

In considering options to mitigate the environmental and human security risks outlined in this paper, interviewees stressed that a vast and complex regulatory landscape exists for mining companies, with country-level regulation often out of date and therefore lagging far behind best practice.¹⁵¹ Mining in the US, for example, is regulated by an 1872 mining law, despite new technological advancements and improved awareness of mining’s impacts.¹⁵² Outdated laws related to mineral extraction often fail to address the complexities and scale of modern-day mining and related harms, leaving mining companies to navigate a complex regulatory landscape.¹⁵³

Numerous guidelines exist detailing best practice for companies and countries in relation to prior informed consent that is freely given, environmental protection, transparency and traceability, community engagement and other elements of due diligence designed to mitigate environmental and social harms.¹⁵⁴ However,
the majority of these standards are voluntary, meaning that they are inconsistently and often inadequately adopted across the sector. Both large-scale and smaller mining companies often do not apply best practice, as financial considerations are often prioritised.\footnote{\textsuperscript{155}} This situation is especially likely where mining occurs in countries with a weak regulatory environment.\footnote{\textsuperscript{156}}

A concerted effort is needed to address this regulatory shortfall. First, best practice, such as International Finance Corporation Performance Standard 6 and practice aligned with science-based targets for nature (SBTN), should, as much as possible, be reflected in national regulations in relevant source countries.\footnote{\textsuperscript{157}} Second, improved consumer requirements are needed for standards around the production of critical minerals (as in the case of the 2023 EU Regulation on Deforestation-Free Products).\footnote{\textsuperscript{158}} Third, capacity of producer countries must be improved to apply regulation and best practice, with technical assistance provided to this end. Development assistance should also be provided to mineral-rich jurisdictions to establish appropriate in-country regulations and build capacity to implement such regulation effectively.\footnote{\textsuperscript{159}} An example of an impactful technical assistance initiative working to improve the mainstreaming of biodiversity into development and infrastructure practice can be seen in the Conservation, Mitigation and Biodiversity Offsets (COMBO) programme, with more initiatives of this type required.\footnote{\textsuperscript{160}}

Improved practice and outcomes following mine development are likely to be stronger if these initiatives are led by governments and civil society, with sectoral initiatives often not aiming for the highest standards, given the need to integrate the views of many parts of industry. Business must be consulted, but should not necessarily be the sole source of information. The mining sector does, however, have an important role to play in applying regulation to achieve positive outcomes, particularly through initiatives such as the ICMM and the Extractive Industries

\textsuperscript{155} Author interview with representative from industry, London, July 2023.
\textsuperscript{156} Ibid.
\textsuperscript{159} Author interviews with representatives from industry, London, July 2023.
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Transparency Initiative (EITI). These bodies have helped catalyse best practice across the industry and engage mining companies and other stakeholders to address the risks associated with the extractive sector. Innovations in mining also demonstrate the possibilities for progress, such as fully electric mines and the sequestration of carbon in tailings, but governments need to identify opportunities to support this work, rather than allowing the initiatives to remain voluntary. The investor community, meanwhile, has a crucial role to play, through initiatives such as the Taskforce on Nature-Related Financial Disclosures (TNFD), and should set targets and report against them to ensure positive outcomes following mine development.

The Role of the UK

The UK can play an important role in leading many of these efforts. The UK government has branded itself as a ‘clean energy superpower’ and a leader in ‘the race towards net zero’, alongside a range of biodiversity commitments. The UK is also uniquely positioned to facilitate action in this area given its role as a global trade, commodities and financial hub. Beyond this, the country is a mining hub, with many of the most prominent and profitable mining companies registered in the UK, and it is also home to industry organisations such as the ICMM.

The UK government should use its unique position in this field to convene regulatory and wider stakeholder communities, ensuring cross-sector buy-in, for example, through the TNFD and SBTN and the Global Reporting Initiative (GRI). The UK should also use its financial and diplomatic position to enter bilateral partnership discussions with governments, while using its convening power to bring stakeholders together to identify and apply meaningful multilateral solutions. The Forest, Agriculture and Commodity Trade (FACT) dialogue, for example, could act as a model for bringing together countries to discuss how to

address critical mineral-related risks, recognising the global scale of the challenge and the need for involvement from supply and demand countries across both the Global North and the Global South. In these ways, the UK can impactfully support integration of high-quality targeted frameworks into this burgeoning sub-sector of mining. While the mining industry is aware of the need to make fundamental changes, and certain companies have made significant progress in key areas, industry-wide change is unlikely unless governments, consumers and investors across society demand it.

Given the criticality of the net zero transition and the minerals it requires, the UK – along with other consumer countries – should also review domestic policies to maximise recovery of critical minerals that are already in consumer supply chains (even as waste). This would reduce waste and improve resilience in supply chains through the creation of an internal market. Interviewees criticised the UK’s current approach as being one of pursuing key net zero milestones in the wrong order, highlighting that the UK currently has a Critical Minerals Strategy but no targeted industrial strategy relating specifically to this area, effectively rendering the former strategy toothless. They also emphasised that there has been limited progress on ensuring that the Critical Minerals Strategy promotes environmental, social and governance standards, with individuals at the verification workshop calling for the government to urgently prioritise and take action on this.

Establishing industry priorities in this space before securing critical mineral supply chains will be key to ensuring that critical minerals are used strategically, particularly in the face of fluctuations in supply. This may be done by establishing which industries should be prioritised in times of shortage: for example, energy, healthcare and transport.

Broadening opportunities for sourcing, aside from extraction via new mines, should also be a future priority. Critical mineral recycling and extended producer responsibility would help minimise many of the risks discussed in this paper, and help in moving towards a circular economy. Currently, 0.5% of lithium and 0.2% of REEs are recycled globally, rising to 32% for cobalt and 60% for nickel. While recycling is not a short-term solution, as time is needed to build the necessary infrastructure, scientists estimate that with optimum recycling the US could meet 30%–40% of anticipated demand for critical minerals such as

170. Author interviews with representatives from NGOs, academia and industry, London, July 2023.
171. Author interviews with representatives from NGOs, academia and industry, London, July 2023.
173. Author interviews with representatives from NGOs, academia and industry, London, July 2023.
lithium, cobalt, nickel and graphite through recycling.\textsuperscript{175} The IEA estimates that recycling could meet 10\% of global demand – with the benefits of recycling much higher for countries that have already embraced clean energy technologies.\textsuperscript{176} Given the pressures that increased demand will put on critical mineral supply chains in the coming years, investment in the necessary recycling infrastructure should be prioritised.

Disposable e-cigarettes (vapes) highlight the need for forward-thinking, circular-economy-driven policies. The UK currently throws away 1.3 million disposable vapes every week, amounting to more than 65 million a year.\textsuperscript{177} The vapes that currently go to landfill each year contain lithium-ion batteries that contain enough lithium, if recycled, to produce 1,200 electric vehicle batteries.\textsuperscript{178} The IEA has warned of lithium shortages as soon as 2025, with lithium recycling a key avenue to securing supplies.\textsuperscript{179} While the recycling of lithium could currently only take place on a small scale, its value as an industry would grow exponentially as more lithium stock enters the economy.\textsuperscript{180} Given the potential of lithium recycling from products such as disposable vapes and the UK’s projected future lithium needs, policymakers should prioritise establishing infrastructure for critical mineral recycling, and recycling more broadly.\textsuperscript{181} To date, domestic progress has been slow. However, the UK’s first industrial-scale lithium-ion battery recycling facility received clearance to operate in 2023 with a forecasted processing capacity of up to 22,000 tonnes of lithium-ion batteries per year.\textsuperscript{182} Yet more needs to be done to reform waste management processes that do not maximise wider opportunities to recover critical minerals. Extended producer responsibility would also help prevent waste at the scale seen in the case of disposable vapes.\textsuperscript{183}

The UK has regulations in place to encourage recovery, reuse and recycling of electrical and electronic equipment (EEE) and will consult on this in relation to critical minerals in 2023, as well as carrying out an assessment to consider the

\textsuperscript{175} Union of Concerned Scientists, ‘Electric Vehicle Batteries’, Fact Sheet, February 2021, p. 3.
\textsuperscript{176} IEA, ‘The Role of Critical Minerals in Clean Energy Transitions’, March 2022, p. 15.
\textsuperscript{178} Critical Productions, ‘1.3 Million Disposable Vapes are Thrown Away in the UK Every Week’.
\textsuperscript{180} Author interview with representative from industry, London, July 2023.
\textsuperscript{181} Author interview with representative from industry, London, July 2023.
\textsuperscript{183} Author interview with representative from industry, London, July 2023.
‘circularity of critical minerals in the UK today as a baseline for future work’.  

However, other work in this area has recently been delayed, such as the extended producer responsibility scheme for packaging, with new rules to ensure packaging producers pay for the cost of recycling their packaging deferred from October 2024 to 2025. Experience of this type raises concerns that proactive steps to support the recycling and reuse of critical minerals could face the same hurdles. Meanwhile, disposable vape producers have already been criticised for not complying with EEE regulations, highlighting the ease with which manufacturers of other critical mineral-based products might avoid compliance.

Given the urgency of the net zero transition, the government should prioritise and fast-track relevant policy initiatives, looking at all options to upscale the UK’s recycling capabilities. At the same time, it should work with manufacturers on extended producer responsibility, the right to repair and design-to-recycle best practice to ensure that critical minerals are reused and recycled wherever possible. The government should also work with manufacturers to reduce the critical mineral footprint in products, using the power of taxation where possible. Car manufacturers, for example, are increasing production of electric SUVs but these need larger batteries, and therefore more minerals and energy, than smaller electric vehicles. In response to this, Norway recently began taxing electric vehicles over a certain weight, a move designed to motivate car manufacturers to be more efficient with their mineral usage. These measures would all serve to reduce demand for critical minerals, thereby helping to secure supply for the industries that most need them. As well as helping to secure critical mineral supply chains, improved domestic recycling has the potential to create jobs and support UK economic growth.

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Social Awareness and Public Engagement

To drive many of the necessary changes, attention to societal-level narratives is also required. Currently, the discourse on the renewable energy sector that critical minerals fuel is supportive: in 2022, polling published by the Department for Business, Energy and Industrial Strategy showed that 88% of people in the UK support using renewable energy.\(^\text{189}\) Meanwhile, polling data by Ipsos and the Centre for Climate Change and Social Transformations showed that in October 2022, the majority of people in the UK continued to support most net zero policies, including electric vehicle subsidies, among others.\(^\text{190}\)

However, as this paper has highlighted, critical mineral mining is associated with a number of environmental and human security risks. If these are left unmitigated, it could reduce support for the net zero transition both domestically and internationally. Given the benefits that critical minerals can bring to both net zero goals and local economies, interviewees stressed that efforts to garner widespread societal support are fundamental.\(^\text{191}\) The empowerment of local communities where mining is taking place and, more widely, of consumers of technology containing critical minerals are both key to ensuring public support for critical mineral mining, and can help facilitate a just transition to net zero.

Community engagement and trust building are key to ensuring mining companies’ social licence to operate and that local communities are partners and beneficiaries of the mineral extraction process. This paper has highlighted the local harms that can occur. However, there are a few examples of mining companies actively prioritising community engagement and ensuring meaningful community oversight of mining activity and the associated benefits.

Mining company Cameco, for example, engaged the English River First Nation (ERFN) in Canada as a partner in a uranium mining project and undertook several years of discussions before a collaborative agreement was signed in 2013 to formalise ERFN’s share of the mine’s benefits.\(^\text{192}\) The agreement set out Cameco’s obligations to workforce and business development, community investment and engagement and environmental stewardship, and committed to regular communications between the two parties to ensure mutual benefit, thereby sustaining ‘high levels of trust’ built on ‘transparency and collaboration’.\(^\text{193}\)

\(^{191}\) Author interviews with representatives from NGOs, academia and industry, London, July 2023.
\(^{193}\) Ibid., pp. 838, 844.
Similarly, lithium mining company Sales de Jujuy has been praised for ‘fostering mutually beneficial and understanding partnerships with localities’ in Argentina\textsuperscript{194} and the Alaskan Red Dog Mine has brought ‘lasting and significant’ benefits to local Indigenous communities, though these are ‘modest’ in the context of the mine’s overall operations and profit.\textsuperscript{195}

The impact of community engagement and trust building can also be seen in the UK context. Cornish Lithium has proactively engaged with the local community, organising community engagement events and Q&A sessions and launching a community fund to contribute to local clubs, charities and activity groups.\textsuperscript{196} This has helped to secure broad support, although concerns about the environmental impact and the potential for wealth from Cornwall’s lithium to be amassed elsewhere remain.\textsuperscript{197} In contrast, Cornish Tin Limited’s plans to explore for and extract tin, lithium, tungsten and other metals from the Wheal Vor tin mine have met local opposition, with a local newspaper noting that ‘there has yet to be a full public meeting where [locals’] questions can be put to Cornish Tin.’\textsuperscript{198} According to the British Geological Survey, areas of the UK from the Highlands to southwest England have the right geology for critical mineral mining, including of lithium.\textsuperscript{199} Meanwhile, the UK’s Critical Minerals Strategy puts emphasis on growing domestic capabilities along the supply chain, which includes domestic mining.\textsuperscript{200} Garnering community support for onshore mining through community engagement is, therefore, crucial.

While examples of mining companies actively engaging with communities are encouraging, this kind of best practice remains largely voluntary and is not the


industry norm across companies or geographies. For this reason, governments should demand best practice on community engagement from companies operating in their territory, with the Global North supporting supply countries in the Global South to demand the same.

Another key element is community empowerment to demand the local distribution of benefits. The potential for success in this area can be seen in the case of the Shetland Community Benefit Fund, an independent cooperative of local communities which is actively engaging with renewable energy companies to ensure that Shetland’s communities ‘benefit from commercial renewable energy developments in the islands’. Similarly, Community Power Cornwall calls for ‘the ownership and integration of renewable energy technologies into everyday lives and settings’, and develops community-owned renewable energy installations.

This, in turn, links to the need for better public understanding and education on mining more broadly. Public awareness of the risks associated with critical mineral mining is key to driving progress on the consumer and investor requirements that are ultimately how a sector – and the governments that regulate the sector in producer countries – will be motivated to make change. Greater public understanding will empower communities to engage with the mining industry in an informed manner. Additionally, public understanding of the importance of critical minerals for the net zero transition will help to boost support for mining projects and reduce demand by ensuring consumers are more mindful about products that contain critical minerals. Equally, such understanding is likely to increase support for circular economy measures to reduce demand, such as design-to-recycle and the right to repair.

Facilitating forums at which mining companies and local communities engage should be a UK priority, to ensure the economic and social viability of plans to mine critical minerals domestically. Internationally, cross-sector, multi-stakeholder coalitions can help to empower local communities whose views are often overlooked in the interests of mining companies, while promoting best practice across the critical mineral mining sector. Examples of this already

exist, such as the Fair Cobalt Alliance\textsuperscript{204} and the Extractive Industries Transparency Initiative,\textsuperscript{205} which can act as models to replicate.


Conclusion

Critical minerals are essential for the net zero transition and for meeting the target set at the UNFCCC Paris Conference in 2015 to limit global warming to 1.5°C above pre-industrial levels. Because of this, demand for these minerals is set to grow rapidly: the IEA projects that up to 28 million tonnes of minerals for green technology will be needed in 2040 – a significant increase from the 7 million tonnes currently mined each year.²⁰⁶

While their potential benefit is significant, this paper has explored the risks associated with critical minerals mining, covering both environmental and human security. At an environmental level, the paper finds key risks to include the potential for critical mineral extraction to contribute to deforestation, water scarcity, soil erosion, pollution and biodiversity loss. In relation to human security, key risks include the potential for critical mineral extraction to contribute to human rights abuses and labour exploitation, crime, corruption and conflict. These issues often intersect, with the biggest impact often felt by local communities, including Indigenous communities on or near whose land mineral reserves may be located.

While many of these risks are already established, this paper highlights the potential for skyrocketing demand for critical minerals to accelerate these harms. This may occur where burgeoning demand incentivises governments to remove or overlook relevant regulations; mandates the opening up of new mining frontiers in countries without histories of extractive operations that lack the infrastructure or capacity to manage the associated risks; exacerbates boom–bust cycles of extractive activity; and increases geopolitical competition.

These risks have very real consequences for the communities and environment they impact. However, the international community – and the UK as a key financial, trade and mining hub – has a range of opportunities to address the risks and minimise the damage associated with critical mineral extraction for the net zero transition. With the world’s attention on the energy transition, there is a prime opportunity to rethink the current approach and embrace emerging

opportunities. Some of these opportunities are not novel in and of themselves but they do require a concerted, strengthened effort to achieve.

Given the high-level focus of this research, this paper does not seek to make context-specific recommendations to address the challenges ahead. However, drawing on research findings, it offers the following overarching recommendations for potential ways forward for key stakeholders to consider. These recommendations are tailored to the UK specifically, in light of the country’s unique positioning to facilitate action in this area, as an international trade and financial hub and a mining hub in which many of the most prominent mining companies are registered. To effectively leverage this position to ensure a just transition to net zero and ensure that the actions and investments required attract long-term public legitimacy, the UK government should consider the benefits of the following, many of which are also applicable to other countries in the Global North:

• Use its role as a mining and financial hub to improve regulation, standards and transparency in relation to investment in critical minerals based on key environmental priorities, for example, through the application of the TNFD, the SBTN, the GRI and similar initiatives, thereby supporting integration of high-quality targeted frameworks into this burgeoning sub-sector. This will reward and enhance uptake of best practice by businesses and support regulation in producer countries globally.

• Develop an updated industrial strategy for critical mineral use specifically, to support the strategic acquisition and use of critical minerals and facilitate prioritisation across key industries should a shortage of critical minerals occur. This should be used alongside the UK’s Critical Minerals Strategy to ensure that critical minerals are used strategically, particularly in the face of fluctuations in supply.

• Given the criticality of the net zero transition and the minerals it requires, review domestic policies to maximise recovery of critical minerals that are already in consumer supply chains, in the form of waste. This would broaden opportunities for critical mineral sourcing aside from extraction via new mines. This should include prioritising the upscaling of the UK’s recycling capacity to facilitate the reuse of critical minerals, mindful of the fact that while recycling alone cannot meet demand for critical minerals, estimates suggest that recycling could meet 10% of global demand, while bringing jobs to the UK in support of the ‘levelling up’ agenda.

• Work with manufacturers on extended producer responsibility, right to repair and design-to-recycle best practice to move towards a circular economy and ensure that critical minerals are reused and recycled wherever possible, thereby reducing demand. This will help to reduce wastage of critical minerals and decrease pressure on supply chains.
• Support improved consumer requirements for standards around the production of critical minerals. An example of this can be seen in the case of the 2023 EU Regulation on Deforestation-Free Products, which could be adapted for the critical mineral sector in the UK and more widely across the Global North.

• Support governments in source countries to develop the infrastructure and capability to manage mining-related risks, providing development assistance to build capacity to apply regulation and best practice, while supporting initiatives that mainstream biodiversity, conservation and social justice into regulation which improves the development and practice of the mining sector in producer countries in collaboration with other actors working in this area, such as relevant aid agencies and multilateral development banks.

• Consider how to integrate innovative concepts and proposals that call for a paradigm shift in our approach to economic activity, human wellbeing and the natural world – such as natural capital assessments through which we can better understand, measure and value human interdependencies with nature, and plan more sustainable management of natural resources – and wellbeing economics. This can be achieved through an approach which prioritises pursuit of human and ecological wellbeing over material growth and has the potential to help us better assess, understand and mitigate the environmental and social harms associated with the mining sector and other sectors dependent on natural resources.
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