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Review

Child Labour in the Extraction of Strategic Raw Materials: A Review and Risk Assessment

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Abstract

In order to meet the Paris Agreement and EU Green Deal, the demand for critical minerals (e.g., cobalt, nickel, lithium, and rare earth elements) is growing exponentially. With their demand arise urgent concerns about the injustices of their supply chain, including concerns about labour exploitation, environmental degradation, and child labour. This literature review examines news media, blogs, governmental and NGO reports, and academic sources to assess the risk of child labour in the extraction of 34 EU-designated critical minerals, 17 of which are considered 'strategic.' Using a combined risk reduction and assessment framework, the study identifies high-risk minerals (cobalt, graphite, nickel, aluminium, copper, and rare earth elements) and high-risk countries (the Democratic Republic of the Congo, Mozambique, India, the Philippines, Indonesia, and Myanmar). The findings reveal the broader negative impact on communities of mining, including increased vulnerability to child trafficking and sexual exploitation. Thus, the risk of child labour does not imply its actual occurrence due to the biased undercount of child labour numbers. Recommendations include further research, raising awareness of children's rights, supporting household livelihoods, and improving traceability in artisanal and small-scale mining to ensure a just transition.

Keywords: artisanal and small-scale mining; strategic critical minerals; child labour; child exploitation; green technology

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1. Introduction

In response to climate change, the European Union (EU) Green Deal has pledged to ensure (1) no net emissions of greenhouse gases by 2050, (2) that economic growth is decoupled from resource use, and (3) that no person or place is left behind—a so-called 'just transition' [1]. The focus of this transition will be away from a reliance on oil and gas, and moving towards more sustainable alternatives, including greener sources of energy and transportation, and becoming climate neutral. Since the implementation of the EU Green Deal in 2019, the focus on materials that are considered economically attractive has shifted towards minerals that are needed for the green energy transition and new technologies, such as machine learning or augmented reality technologies [2,3].

Critical minerals are "raw materials of high economic importance [. . .] with a high risk of supply disruption due to their concentration of sources and lack of good, affordable substitutes" [4]. The supply of critical minerals has become a "strategic security question" as they are needed to meet the demand for mobile phone technology, electric cars and aircraft, wind turbines, and the production of glass and fertiliser [3]. The EU Green Deal has changed the critical mineral industry not only by redefining which minerals are considered

critical but also by creating an increased urgency to meet the demand for their production. Meeting the net zero goal by 2050 would require six times the amount of critical minerals produced today [5].

The economic importance of critical minerals that are needed for the green energy transition and new technologies has been driven by policy, demand, and consumption—not only within the EU but worldwide (e.g., [6]). Thus, the supply chain of critical minerals is global, meaning that "[actions] that happen at a local level in terms of mining operations are all influenced by what happens at a national and international level" (p. 860, [7]). The European Council has identified 17 strategic raw materials (SRMs) which form a subgroup within critical minerals (see pink circles in Figure 1). This subgroup of minerals is particularly important because these minerals have complex production requirements, their demand is expected to grow exponentially in the coming decades, and they have specific risks of supply chain disruption. They have a particular global relevance to the critical mineral industry.



Figure 1. Overview of SRMs (in pink) as per Regulation (EU) 2024/1252 of the European Parliament and of the European Council (2024).

The supply chain of SRMs, specifically the sourcing and extraction processes, is known for its ethical controversy around the question of justice and equality [7]. Materials like cobalt, gold, or mica have historically received a lot of attention, specifically regarding their unethical sourcing practices [8,9], including the presence of child labour. Child labour in the context of mining is considered one of the worst forms of child labour ((a) all forms of slavery or practices similar to slavery, such as the sale and trafficking of children, debt bondage and serfdom, and forced or compulsory labour, including forced or compulsory recruitment of children for use in armed conflict; (b) the use, procurement, or offering of a child for prostitution, for the production of pornography, or for pornographic performances; (c) the use, procurement, or offering of a child for illicit activities, in particular for the production and trafficking of drugs as defined in the relevant international treaties; (d) work which, by its nature or the circumstances in which it is carried out, is likely to harm the health, safety, or morals of children (C182—Worst Forms of Child Labour Convention, 1999 (No. 182))). Mining has a multitude of negative impacts on children, with the most severe being its risk to children's mental and physical health [10]. While its prevalence is difficult to determine, the most recent numbers indicate that over 1 million children are engaged in child labour in the context of mining and quarries [10–12]. The following characteristics of the mining industry and the global supply chain of critical minerals have been associated with child labour [10]:

1. Certain types of mining practices, such as **artisanal and small-scale mining (ASM)**, have been identified as frequently exploiting children for work (with a high risk for the worst forms of child labour). Considering that ASM employs 44.75 million people globally, the exploitation of children for the worst forms of child labour within the context of mining is a highly relevant topic.
2. The **extraction, export, import, and production** of critical minerals is a process that follows a global supply chain, and many of these steps are known for their omnipresence of child labour risks.
3. The **global supply chain** of critical minerals is characterised by a lack of transparency, and the high demand for critical minerals fosters an industry climate that has been found to increase the risk of child labour taking place, such as ag-gressive pricing structures, unrealistic turnover time, and unpredictable order volume.

A concerted effort to better understand ethical issues that occur at each step of the supply chain is incredibly important. In the face of such urgent demand, it is crucial to understand the impact of the SRM extraction and supply chain on children in particular. The risk factors outlined above highlight the importance of investigating the risk of child labour occurring in the process of mineral extraction. It requires special attention to communities that are affected by the production and logistics of the supply chain and the workers within it. The aim of this review is therefore to determine the risk of child labour occurring in the extraction process of SRMs, with a focus on ASM. While the focus is on child labour in the extraction process, this review also considered other forms of child exploitation where relevant, and the occurrence thereof, in the wider supply chain of SRMs.

2. Child Labour in the Mining Industry

Due to widespread mechanisation in large-scale mines and national legislative reforms, child labour globally declined in the 20th century. However, child labour did not disappear from all types of mining. In ASM, child labour persists, and while the ways in which and the reasons for which child labour persists are manyfold and context-specific, some conditions that risk the occurrence and persistence of child labour have been found:

- Certain contexts are considered to be under the "resource curse", which is that idea that countries that are rich in valuable raw materials, such as oil or minerals, suffer from long-term negative impacts due to the poor economic growth. Thus, a case study in Colombia found that the presence of the resource curse increases employment opportunities but also increases the presence of child labour [13]. Other studies have found that the resource curse is associated with increased informal economic activities [14].
- In other contexts, ASM is a trade that is being carried on from one generation to the next [15]. In the presence of an increasing demand in minerals, the employment opportunity within a trade that is already within the family is an attractive economic activity.
- Climate change can have a negative impact on agricultural productivity. In areas where people are dependent on agriculture, ASM may become a survival strategy in which all members of the family may need to contribute [16].
- ASM often occurs in remote areas in which law enforcement is limited or not present at all. Here, child labour laws that prohibit the worst forms of child labour are not governed and enforced [17,18].

The COVID-19 pandemic had further negative impacts for adolescents that fall under the category of "last mile adolescents." Last mile adolescents are defined as adolescents between the ages of 10 and 19 who meet any of the following criteria [19]:

- Identify as Indigenous;
- Are rurally located;
- Belong to a sexual, gender, religious, or ethnic minority;
- Are out of school;
- Live in extreme poverty;
- Work in ASM.

The pandemic put last mile adolescents at risk as the consequences of the pandemic had a lasting impact on their (family's) income and their access to health and education. ASM presented itself as an attractive activity because it gave adolescents the opportunity to diversify their (family's) income, reduce their poverty, and finance their education. However, involvement in ASM came with lasting impacts, such as reduced school attendance, dropping out, and high health and safety risks [1].

3. Materials and Methods

3.1. Study Design

Given the relatively scant information on this topic, a literature review was deemed most suitable, including searches of the academic and grey literature, as well as a review of traditional, local, and business news media. We aimed to put the information that did exist together in a comprehensive overview to investigate whether there are indicators of risk regarding the occurrence of child labour.

The first stage was a broad review of critical minerals and their global supply chains. This also informed the decision on an appropriate theoretical framework that fits the context of mineral extraction and global supply chains. This step has also informed the decision to limit the scope of our research to (1) the subgroup of SRMs and (2) only investigating the top five exporting countries of each critical mineral. The second step of the desk review identified the top five exporting countries for each SRM with the help of the publicly available Observatory of Economic Complexity database from 2022. Then, each exporting country was researched for the presence of previously identified vulnerability and severity factors (see Section 3.2 for details) within their SRM industry and national context. For the present publication, we highlight the countries with the highest risk and most reliable data. See Figure 2 for a flow diagram of the study design:

3.2. Theoretical Framework

A risk reduction approach was selected so that the focus was on the potential of child labour occurring rather than unreliably claiming the actual occurrence thereof. Traditionally, risk is assessed using two interplaying key metrics, namely the probability of an event occurring and the severity of the event [20]. We applied this formula to the risk of child labour occurring in the mineral extraction industry. Given the scarce research on child labour within the critical mineral industry, we chose to operationalise probability in terms of vulnerability that was assessed qualitatively. This approach is in line with previous risk reduction approaches that claim that risk cannot and should not always be assessed quantitatively and use vulnerability as a starting point to better understand risk [21,22].

To clarify, in the context of our research, we understand this risk as the probability of an event occurring in the form of the community's vulnerability to suffering damage from the emergence of extractive industries, and severity as indicated by the impact that critical mineral extraction has on the local community (see Figure 3).

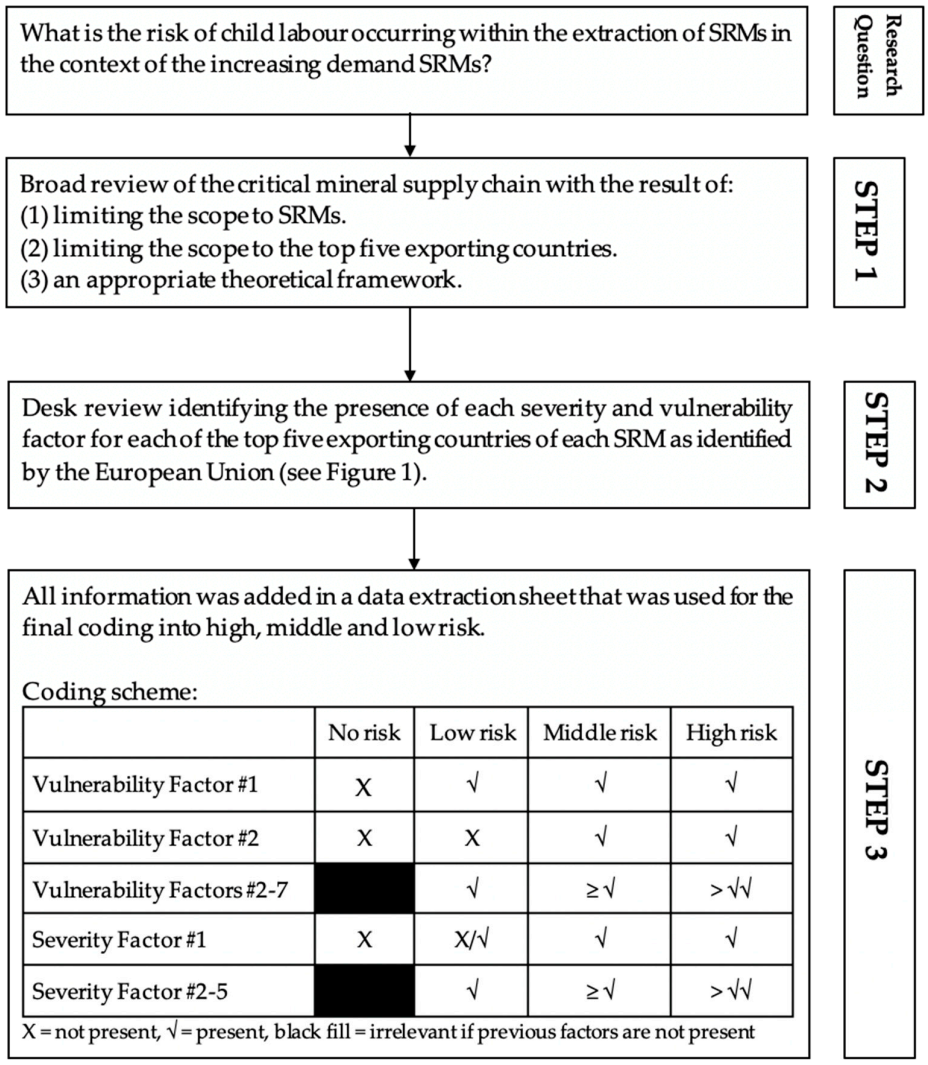

Figure 2. Flow diagram outlining the research step by step.



Figure 3. Risk assessment metric for determining likelihood of occurrence of child labour in the mining process of SRMs.

The conceptualisation of severity and vulnerability is based on the previous academic literature that defines vulnerability as a susceptibility and/or intrinsic predisposition to suffer damage [22]. Thus, vulnerabilities are thought to include factors of resilience, coping strategies, and capabilities, as well as capacities which include resources and assets people possess and have the ability to access. Severity indicates the anticipated impact caused by an event [20].

For this purpose, we have identified common factors that are associated with child labour, to qualitatively assess the vulnerability and severity. The following factors were chosen (see Table 1):

Table 1. Overview and details of all vulnerability and severity factors.

Type of Factor	Factor	Impact on Risk	Description
Vulnerability factor	Occurrence of modern human slavery, forced labour, and child labour	High	The existing presence of modern human slavery, forced labour, and child labour increases the risk of child labour occurring generally and within the industry of critical mineral mining. Thus, contexts that have a history of modern-day human slavery, forced labour, and child labour within the extraction industry are at an even higher risk. To assess the presence of modern-day human slavery, forced labour, and child labour, we used two assessments. The first was a heat map developed by Berthet and colleagues [21] that visualises the Global Slavery Index score for a given country. The second indicator that was used was the report on the worst forms of child labour [23], which indicates whether there are child labour and forced labour reports and whether there is any advancement on the issue to be observed in the given country context.
	Known presence of ASM or illegal mining operations	High	Through a review of the academic literature, news reports, NGO reports, private sector reports, and governmental reports, we tried to assess whether ASM or illegal mining activities were present in (1) the given country and (2) the given mineral context. In the past, ASM activities have oftentimes been associated with child labour and are indicated to be a risk to children's rights, thus increasing the susceptibility of a given context towards the occurrence of child labour [10,11]. ASM is a category of mining that mostly involves non-mechanised, simple tools and techniques that are often labour-intensive and carried out by a small group of individuals or communities. Yet, it can include operations that are more capital-intensive [2]. ASM is considered an informal sector, but it is not necessarily illegal. The legality of ASM operations depends on national regulations.
	Climate change impact in the specific country and/or region	Medium	Through the stress and loss of protective environments that climate change can cause, children's vulnerability to exploitation can be increased [21]. Child labour has occurred as a response to climate change shocks [24], and the disruption of safety nets due to the consequences of climate change increases their vulnerability to child labour and other forms of exploitation, such as sexual violence, early marriage, trafficking, and recruitment to armed groups [25–27]. Further, research has found that child labour has been used as a coping strategy to deal with climate-related shocks [16,25,28]. To assess climate change impact, we consulted the Climate Risk Index for each country.
	Economic dependence on threatened industries	Low (based on dependence on previous factor)	Climate change impacts can result in a loss of livelihoods. The livelihoods of poor and marginalised people are particularly threatened [28]. People who are highly vulnerable to a loss of livelihood due to climate change are often engaged in agricultural activities, agroforestry, or fishery.
	Sociocultural attitudes towards child labour	Low	Culture is considered to be a critical factor when exploring the root causes of child labour. Thus, it is not the presence of particular norms that may justify child labour but the interpretation of such norms in a given context; e.g., it may lower the threshold of sending your child to work in the context of economic struggle [29]. Thus, child labour itself is not a central tenet of a country's or region's culture.
	Poverty levels	Middle	To assess poverty, the IDEA database from the U.S. Agency for International Development (2021) was consulted. Poverty is a well-known driver of child labour, and has been found to be most pervasive in countries with low income levels [30].
	Other contextual factors	Low to middle	Emergencies are thought to exacerbate the worst forms of child labour. These emergencies can include trade tensions, violent conflicts, or health pandemics. The stress caused by the emergency and economic pressure on the supply chain to deliver may impact decision-making and resilience, which can result in an increased vulnerability to the worst forms of child labour [25–27].
Severity factors	Education statistics	Middle	Education data is also derived from the U.S. Agency for International Development's IDEA database [30]. Most children involved in child labour are not able to attend school anymore. If they are, their school attendance and attainment are likely to be lower as they may need to work during school hours or their capabilities may be limited due to physical and mental exhaustion from the labour.
	Reports of environmental impact of mining	Middle	Direct influences of mining industries on environmental pollution and degradation can induce negative effects, such as loss of livelihoods, as exemplified by previous case studies (e.g., [31–33]).
	Reports of displacement for mining projects	Middle	Displacement of local populations in the context of opening mining projects has been reported to negatively affect livelihoods (see case studies such as [32,33]).
	Reports of illegal natural resource industry	High	Illegal activities in mining have been found to have the potential to exacerbate the negative environmental impact of mining due to lack of environmental considerations. Further, illegal mining activities are related to inadequate working conditions and the presence of organised crime [34] (see reports such as [35,36]).

Notably, these are not stand-alone factors contributing to an increased likelihood of child labour occurring in the SRM mining sector. They intersect with each other and will be assessed as such for this study. For example, a large quantity of people living below the poverty line in combination with sociocultural attitudes that see labour as a part of a child's 'socialisation process' intersect in their contribution to an increased risk of child labour occurring. Sociocultural attitudes alone are not an indicator of child labour.

Lastly, these factors are not direct evidence of the presence of child labour in the context of SRM mining. Considering the fast pace at which the demand of SRMs is developing, it is crucial to highlight potential risks for children in the areas where extraction takes place to ensure a "just transition." The risk indicator should not be taken at face value and needs to be considered for future research.

3.3. Data Extraction

After selecting the risk reduction approach and defining relevant factors that indicate vulnerability to child labour, we looked in detail at each of the 17 SRMs by consulting academic databases, news media, and both governmental and non-governmental reports. We started by assessing each vulnerability and severity factor (see Table 1). For each, the database of the Observatory of Economic Complexity was consulted, which reveals the top five exporters according to the most recent available data [37].

We used search engines and academic databases to explore the topic, including search strings "[strategic raw material]" "[country]" "[illegal mining]" followed by another search with the search string "[strategic raw material]" "[country]" "[artisanal small-scale mining]". If relevant information was found, follow-up research was conducted to verify or cross-check this information. We qualitatively assessed 41 countries (countries investigated: Australia, China, Guinea, Brazil, India, the DRC, Russia, Canada, Cuba, Chile, Peru, the USA, Mozambique, Madagascar, South Korea, Indonesia, the Philippines, New Caledonia, Germany, Hong Kong, South Africa, Gabon, Ghana, Kenya, Norway, Myanmar, Malaysia, Vietnam, Japan, Argentina, Belgium, the United Kingdom, Rwanda, Bolivia, North Korea, Spain, Turkey, Luxemburg, and Italy) based on the level of risk of child labour occurring and the quantity of other SRMs that are being exported from the country.

Throughout the search process, all the literature containing information about the presence of potential risk factors was documented. After the research for each factor was completed, the information was summarised in an Excel sheet that outlined all risk factors per SRM and respective country to obtain a comprehensive overview and organise the data according to the framework. Lastly, the level of risk was assessed qualitatively (no risk, low risk, middle risk, or high risk) based on the number of severity and vulnerability factors present in a given context.

3.4. Data Analysis

After the research for a given SRM and country context was complete, the data was analysed by reviewing how many risk factors were present and how strong the evidence indicating risk was. The country context for each respective raw material was then coded as "no risk," "low risk", "middle risk," or "high risk." All the literature was added to an extraction sheet and categorised according to the different factors. Based on the number of severity and vulnerability factors present in a given context, the level of risk was assessed.

3.5. Ethical Considerations

This study did not include collection of primary data. All data was gathered from publicly available information.

4. Results

In the following, we will discuss the contexts in which a high risk of child labour occurring within SRM extraction was assessed. Countries with a low-to-medium risk are not discussed. The limited accessibility of reliable data does not allow for reliable differentiation between low- and medium-risk countries. Further, the goal of the research is to draw attention to the risk and present a preliminary overview of *potential* at-risk countries. The lack of reliable data does not allow for an assessment of the actual occurrence of child labour. It is important to highlight that future research should be conducted and updated information should be consulted before making claims regarding the risk or presence of child labour within the SRM industries of these countries. The present research is not a final assessment and merely serves the purpose of guiding future research and investigation.

For an overview of the (non)presence of each vulnerability in the presented contexts, see Table 2. Note that you can find an elaborate outline of this table for each mineral–country context in Appendix A.

4.1. Cobalt

Cobalt is known as a 'battery mineral.' It is used for lithium-ion batteries as part of electric vehicles, computers, smartphones, and e-cigarettes [2,38]. It is also used in jet and gas turbines, alloys for powerful magnets, electroplating, and special paint. The magnetic properties and the high heat and corrosion resistance of cobalt make it a suitable material for these purposes. Thus, it is an important mineral for aerospace, defence, medical applications, and clean energy technologies [37]. The waste products of cobalt are toxic and can pollute water and contaminate crops, negatively impacting agriculture and fishery. Cobalt mining also pollutes the air, which can have an adverse effect on health [39]. Other health effects in the context of cobalt mining have been found to include respiratory diseases and birth defects [40] (note that the health concerns relate to unregulated mining activities).

Cobalt in the Democratic Republic of the Congo (DRC)

The Copperbelt region in the south of the DRC is well known for its cobalt mining. The main regions for cobalt mining within the DRC are Lualaba and Haut-Katanga [36]. The Copperbelt region also extends to Zambia. In this region, cobalt is often extracted as a byproduct of copper or nickel [41–43].

In the past two decades, numerous news and media outlets have published reports, pictures, and videos showing the presence of child labour in the mines of the Copperbelt region. At present, the occurrence of child labour at cobalt mines in the DRC is common [21,44]. A total of 15–20% of the cobalt production from the DRC stems from ASM sites which are known for informal and extremely hazardous work conditions, child labour, and low entry barriers into the job [45]. There has been little advancement in improving the cobalt sector in the DRC. Specifically, in regard to child and forced labour, the DRC has made only minimal advancement [24] and remains a context with a high vulnerability towards the occurrence of modern-day slavery [21].

Table 2. Overview of (non)presence of vulnerability and severity factors in each country. The 'X' marks indicate the presence of a factor, while the black space indicates its absence.

Type of Factor	Factor	Weight	Cobalt and Copper in the DRC	Nickel in Indonesia	Nickel in the Philippines	Graphite in Mozambique	Graphite in Madagascar	RRE in Myanmar	Aluminium in India
Vulnerability factor	Occurrence of modern human slavery, forced labour, and child labour	High	X	X	X	X	X	X	X
	Known presence of ASM or illegal mining operations	High	X	X	X	X	X		X
	Climate change impact in the specific country and/or region	Medium	X	X	X	X	X	X	X
Severity factors	Economic dependence on threatened industries	Low (based on dependence on previous factor)	X	X	X	X	X	X	X
	Poverty levels	Middle	X	X	X	X	X	X	X
	Other contextual factors	Low to middle	X	X	X	X		X	X
	Education statistics	Middle	X	X	X	X	X	X	X
	Reports of environmental impact of mining	Middle	X	X	X	X	X	X	X
	Reports of displacement for mining projects	Middle	X	X	X	X	X	X	X
	Reports of illegal natural resource industry	High	X		X	X	X	X	X

The cobalt mining industry is both hazardous to the environment and the people living in it, with its negative environmental impact, hazardous working conditions, and low pay [45]. Simultaneously, the main source of sustaining food and economic security in the DRC is agriculture. The agricultural sector is suffering from the effects of cobalt mining through the pollution of the soil and contamination of water sources. Agriculture is already projected to suffer heavily from climate-related shock, such as floods and droughts [24,39,45]. It is a much-needed means of sustaining food and economic security in a context in which 92.1% of the population live on less than USD 3.65 a day [30]. Poverty is one of the main drivers of child labour in the DRC [46], and there is little opportunity for families and their children to improve their situation [23]. Contextual factors of war and forced displacement pose another risk to children's well-being, with 78,000 children being considered as displaced [46–48].

Given the direct evidence of child labour at cobalt mines in DRC and at land fill sites from bigger cobalt mines, the DRC is at an extremely high risk for child labour to occur and continue to occur in and around mines. In the context of the Copperbelt region and the specific risks of child labour occurring there, it is important to highlight that the Copperbelt region stretches over the border to Zambia. Future research and investigations should investigate the existence of similar patterns in Zambia.

4.2. Copper

Copper is a great conductor of heat and electricity, which is why it is often used in electrical equipment for wiring and motors. It is essential for most forms of renewable energy [49]. Copper extraction can produce cobalt as a byproduct [5,49], and the extraction process requires a large amount of water, draining water resources that are often already limited. Environmentally, water pollution and water stress resulting from copper extraction is the biggest concern [50].

Copper in the DRC

Copper in the DRC is also mined in the Copperbelt region [44,51,52]. Despite less reporting on copper in the context of the DRC, it is likely to observe the same dynamics of child labour and exploitation in the extraction process of copper as in cobalt, as copper produces cobalt as a byproduct and is thus extracted at the same place.

4.3. Nickel

Nickel has the ability to resist corrosion, making it suitable for protective plating in a variety of home products. Further, it is used both inside and outside of electronics as well as for rechargeable batteries in hybrid vehicles. Nickel extraction is very harmful to the environment, with major concerns being water pollution, habitat destruction, air pollution, deforestation, and soil pollution and degradation [53]. Health concerns in the context of nickel mining include respiratory diseases, cancer, and cardiovascular disease [40].

4.3.1. Nickel in Indonesia

Nickel is mined in six regions in Indonesia: Central Sulawesi, South Sulawesi, Southeast Sulawesi, North Maluku, Maluka, and Papua [54,55]. Large-scale nickel mines and smelters are known for hazardous working conditions [56]. Further, the country generally struggles with illegal mining activities and illegal trade of extracted goods [57]. In the case of nickel, ASM activity in Indonesia has been reported. There are also direct reports of forced labour in nickel extraction [24,58]. Geopolitically, the nickel industry in Indonesia is complicated by Indonesia's attempts to become more independent from China. These attempts have resulted in considerably lower production and extraction in 2023 [59–61].

Nickel mining in Indonesia has also harmed the environment and worsened the impact of climate change in Indonesia. The projections include more extreme weather events (e.g., floods and droughts) and long-term changes in sea levels, rainfall, and temperature patterns [62]. Nickel mining is known to be highly toxic, and the extraction activities have resulted in severe pollution—by both small- and large-scale mines. The pollution of water and soil has impacted children's health and livelihood. Thus, nickel extraction does not only directly negatively impact people's health but also threatens the livelihood of millions of people that depend on agriculture and fishing [60–63]. As there are certain norms that do not necessarily oppose child labour, for example, seeing labour as having a positive effect on children's maturation process and not necessarily harmful [64], the vulnerability of child labour occurring in times of need is heightened.

On top of the polluting effects of mining and climate change, the opening of mines is risking the livelihoods of communities further through land-grabbing activities and violent displacements. Voices of opposition are pushed back by the government, and social and economic disadvantages for opposing voices have been implemented [62,65,66].

4.3.2. Nickel in the Philippines

Nickel is also mined in various places in the Philippines. The mining hotspots are considered to be in the Cordillera Administrative Region and Caraga [67]. Other known regions include the island of Sibuyan and the state of Mindoro [68–71]. The presence of ASM in nickel extraction in the Philippines has been deemed as likely considering the persistent issue with ASM in the Philippines [58,70–73]. In the past, the small-scale mining sector in the Philippines has had incidences of child labour [73].

Almost a quarter of the work force in the Philippines depends on agriculture. Nationally, agriculture is the primary source of income [30,74]. Another important source of income is fishery and aquaculture. All three of these industries are threatened by the high risk of climate change impact that is projected for the Philippines [74]. The environmental pollution caused by nickel mining activities exacerbates the impact of climate change and concurrently the negative impact on the main sources of income for many Filipinos. Evidence of the impact of nickel mining activities can already be seen in negative health effects in communities living close to mining sites [75].

The nickel industry in the Philippines is not without its challenges, with China maintaining a lasting influence [72,76] and allegations of severe human and labour rights violations within large-scale mining operations [77,78]. The opening of these operations has been a topic of controversy as it has been associated with land-grabbing activities, which have been identified as a driver of child labour [79].

Environmental activists and protesters opposing the opening of mines have been violently disrupted, creating an atmosphere of fear in which mining is becoming a dangerous topic [80].

4.4. Graphite

Graphite is another "battery mineral" [81]. Graphite should not be confused with diamonds based on their common origin in carbon ores; however, graphite has a different chemical composition. With its high thermal and electrical conductivity, it is used for a variety of purposes such as lubricants, insulation, and reinforcement products. Graphite is particularly important for the automotive industry, with uses in electrical motors, brake linking, gaskets, and clutch materials [81,82]. Graphite extraction raises concerns over air pollution and deforestation for the purpose of gaining land for extraction sites.

Graphite is assessed as one of the minerals with the highest supply risk based on its geopolitical exposure, and the lowest average in social and governance scores [83].

4.4.1. Graphite in Mozambique

The ERPM [58] reports the presence of ASM activity within the graphite industry of Mozambique, while other sources report that the presence of ASM activity is unclear [84]. Graphite in Mozambique is mined in Cabo Delgado, a region in Mozambique with an ongoing violent conflict and violent activities by local terrorist groups. Here, half a million Mozambicans have been displaced, and it is an extremely dangerous situation for children [85–87].

According to the Climate Risk Index, Mozambique is one of the most at-risk places in the world, and the population is vulnerable to suffering extreme consequences in the face of a disaster [88]. It is estimated that climate change will drive another 1.6 million people into poverty by 2050, and there is a specific threat to agricultural practices [89,90]. The latter represents an extreme challenge for Mozambican children, 49% of whom live in absolute poverty, and with 70% of all Mozambicans relying on agriculture, the livelihoods of the majority of the population are at risk [30,90,91]. With the urgent and increasing demand for graphite, graphite mining may remain the only source of income for some in Mozambique. Since ASM is common in Mozambique [58,92], it is not unlikely that people may start to use the same practices for graphite.

Overall, children are at risk in Mozambique, with little advancement on combatting child and forced labour. Around 2 million children have been orphaned, meaning they are outside of parental care; there is also a high prevalence of HIV in children, and children are vulnerable to different types of exploitation, including child labour [24,93–95].

4.4.2. Graphite in Madagascar

Graphite mines in Madagascar are predominantly large, formalised mines, yet small-scale mining permits have been given out, and according to the ERPM [58], ASM activity in graphite extraction in Madagascar is present. Approximately one million people are engaged in ASM in Madagascar [96], and recent research predicts that child labour in graphite mining will increase by 2030 [97].

In the face of being one of the most at-risk countries for the impacts of climate change, it is crucial to consider the impact on the livelihoods of the more than 85% of the population who depend on agriculture [30]. Graphite mining has an adverse effect on the environment and has forced migration on people who previously relied on their land for agricultural production [98]. A threatened livelihood for the majority of people and extremely low educational quality creates an environment in which children are often disadvantaged and their well-being is threatened.

Formal reports of child labour in graphite mining in Madagascar are not present. Nonetheless, Madagascar's context does pose a risk to children's well-being, and there are mining sectors in Madagascar which are known for child labour and trafficking [24]. Lastly, recent research projections indicate that child labour in graphite mining is likely to increase in the coming years [97].

4.5. Rare Earth Elements (REEs)

REEs are crucial components for many applications, including magnets, batteries, and catalytic converters [99]. Normally, a distinction is made between heavy and light elements; however, there is only limited data available that outlines the top five exporters distinguishing between the two. The extraction of REEs can be a source of hazardous waste and pollutants that can affect water, soil, air, and the human body. Environmentally, water pollution and soil pollution are a specific concern [100]. While human health concerns are difficult to specify without extensive research [17], previous mining sites such as the one

in Baoutou in Inner Mongolia have observed high incidences of lung cancer, brain cancer, respiratory illnesses, and cardiovascular diseases [1,2].

Rare Earth Metals in Myanmar

The REE industry in Myanmar is mostly illegal. Most reports indicate no adherence to safety and environmental regulations. Some reports also indicate the presence of child labour in the REE extraction industry in Myanmar [101,102]. The extraction sites do not necessarily fall under the traditional category of ASM due to their relative large scale, but they overlap with ASM in regard to being informal, not adhering to environmental and safety regulations, and being associated with organised violence [101–104].

Within the extraction of REEs in Myanmar, there are reports of severe water pollution that affects drinking water sources and has poisoned livestock [101]. Myanmar is already ranked as the second most at-risk country for climate change, and in combination with the violent insurgency that has a negative impact on the environment [105], the climate change risk in Myanmar is extremely high. This threatens the livelihoods of people living in rural areas who depend on agriculture, fishing, and forestry; as agriculture remains the largest sector in Myanmar, it provides a livelihood for many [106]. In the face of illegal land-grabbing and almost 50% of the population living in poverty [101,107,108], many are at risk of being affected by natural disasters and political unrest.

Such an extreme situation is likely to increase the risk of child labour occurring, especially in a context in which children traditionally contribute to the collective well-being of the family [109]. The main risks for children include (forced) displacement and being exposed to the risks of a violent conflict, including attacks, forcible recruitment, early and forced marriages, arbitrary arrests, detention, abuse, and deprivation of critical services, such as education and health [110]. The lack of access to critical services is represented in the decrease in school enrolments and an increasing number of children being out of school [110]. Coupled with a heightened demand for REEs, illegal activity around their extraction, and a dangerous political environment, and considering that there has been no advancement on eliminating child labour [24], the risk of child labour is generally high. This risk includes the REE extraction industry, in which reports of child labour have been mentioned [101].

4.6. Aluminium

Aluminium is found in minerals such as bauxite and cryolite. The majority of the literature on this mineral and its supply focuses on bauxite. Based on its malleability, thermal conductivity, and non-magnetic property, aluminium is an SRM that is used as a construction material for various methods of transportation, including aircraft, electrical transmission lines, and coating for applications, using light and heat. The mineral extraction of aluminium mostly happens via open-pit mining, which is a process that requires a large quantity of water, threatening water availability, while also posing a threat to severe water and soil pollution and contamination [111].

Bauxite/Alumina/Aluminium in India

In India, bauxite is mined in various states, including Odisha, Chhattisgarh, Jharkhand, Maharashtra, Gujarat, Goa, Karnataka, Madhya Pradesh, and Tamil Nadu [112]. According to the Indian government, the bauxite mines are all formalised. However, there are reports of illegal activities in the states in which bauxite is being mined as well as directly at bauxite mines, including corruption, illegal mining activities, and operation of mining mafias [35,58,113–115]. While these illegal mining activities are mostly operated by bigger corporations, the lack of oversight in regard to labour rights and fair work conditions poses a risk of child labour occurring.

Furthermore, India is at a high risk for climate change impacts and is among the top ten most at-risk countries [30]. The expected and experienced impacts include increasing temperatures, droughts, and falling groundwater levels [116]. In combination with the contamination that bauxite mines cause, the livelihoods of people are threatened in areas in which mining occurs. Livelihoods are lost due to forced displacement for the opening of mines and mining pollution and climate change negatively impacting agricultural livelihoods.

Considering that more than half of the Indian labour force is dependent on agricultural livelihoods [30], there is an increased risk that bauxite mines have a negative impact on the lives of children. In combination with the political climate in which local communities are scared to report illegal mining activities and speak out about the issue, there is a lack of oversight of the presence of illegal activities [117].

The combination of threatened livelihoods and illegal mining activities is further complicated by high poverty levels in India. Some states in which bauxite mining takes place, such as Odisha, have especially high poverty levels. In the presence of limited access to quality education for economically disadvantaged and rural children, the opportunities to move out of poverty are limited.

Overall, child labour is a persistent issue in India, with medium-to-high vulnerability to modern-day human slavery [21] and reports of the worst forms of child labour [24]. In combination with high poverty levels and threatened livelihoods, families may have no other opportunity to survive than to include their children in the workforce. The occurrence of mines in rural areas threatens the well-being of children further. This impact is not only felt through the reported environmental degradation that mining activities cause but also in past reports of child labour around bauxite mines in Odisha [118].

Overall, the regions in which aluminium mining is taking place have high numbers of child labourers [118,119].

5. Discussion

Globally, child labour has been identified as a widespread and common issue that is "hidden below the surface" [10]. The fast growth of the green energy industry and the ever-changing patterns of the global supply chain call for an urgent assessment of its impact on children, and specifically their risk of being involved in child labour.

The present research assessed the risk of child labour occurring within the extraction process of SRMs in a given country and industry context, using a risk assessment framework. While the present research does not aim to report the actual presence of child labour, it is aimed at guiding further research and investigation, and at raising awareness that the risk of child labour in this fast-paced industry exists. The findings of this assessment show that there is a considerable risk of child labour occurring in the SRM extraction industry, particularly among the top exporting countries. We qualitatively assessed each of the 17 SRMs and the countries from which they are imported.

The investigation highlights how already-existing vulnerabilities intersect with the impact that extractive industries have on local communities. For example, across all contexts, there are reports of mining pollution that negatively impact agricultural livelihoods—which in all contexts make up almost at least a quarter of the country's labour force. The effects of mining pollution exacerbate the already-existing problem of climate change negatively affecting these livelihoods. While the direct outcomes of these intersecting dynamics are strongly context-dependent and cannot be predicted without in-depth research, we can conclude that the global supply chain of SRMs has an impact on the local level [7], and that these impacts influence children and their future.

Although this research identified child labour as a concern in seven countries where critical minerals are mined, understanding of the patterns of child labour is always context-dependent. The risk of child labour occurring at ASM sites is often higher than large-scale mines (see [10]), yet the complexity of the dynamics of ASM should not be forgotten. For example, field work in the Philippines has shown that the opening of large-scale mines influences the presence of ASM but does not necessarily eliminate its existence. This indicates the importance of field work to understand the specific impact SRM mining has on communities.

Moreover, when considering examples such as copper and cobalt extraction in the Copperbelt region, it becomes clear that the dynamics of labour exploitation are complication and may not be restricted to national borders. This again highlights the need for field research and understanding local dynamics and contexts.

Lastly, it is important for future research to unpack the widespread negative narrative around ASM sites (e.g., the 'large-scale mining bias' [120]) There are situations in which miners at ASM sites are victims of trafficking, labour, or human rights abuses, and are trapped in poverty [17,121–124]. In other contexts, such as Tanzania, ASM is a trade that is taught from one generation to the next and has a tradition within some communities. In such contexts, there is a sociocultural dimension that should not be overlooked [125]. These dynamics should be considered when studying the risks of SRMs within a specific context and should not be over-generalised.

5.1. Limitations

The exploratory nature of this research needs to be considered when discussing the findings. First, the conclusions drawn from this research are based on publicly available data, and as such are subject to the poor transparency of certain information and an overall lack of data on this topic.

Second, this lack of data also directly influences the final assessment of the degree of risk. The assessment of risk was performed qualitatively, which allows a consideration of the broader context, which is very important in preliminary research. However, it is also less comparable, and combined with limited access to reliable data, the conclusions drawn from the research should only be viewed as a guidance for future research and not as an end product.

Third, a full understanding of a specific context requires a deeper investigation of the country context, its culture, and how the different risk factors within this context intersect with each other. As an example, cultural contexts are more complex and intersect with other risk factors. The way in which a given cultural context may enhance the likelihood of child labour occurring differs depending on the context: for example, in Latin America, child labour is associated with the mining culture and traditions associated with it, whereas in Southeast Asia, it is associated with the exclusion of women in the economic contribution to family income, and in Africa, it is more associated with the intersection of poverty and family norms [126].

Lastly, based on the methodology used, only countries that were relevant to global trade based on their export data were analysed. Future researchers should check whether there are any new developments within the global supply chain of a given mineral when making a decision on their focus. Simultaneously, future research should take into consideration that export does not equal extraction. The supply chain of SRMs and critical minerals is, like many other supply chains, not fully transparent, meaning that there might be other countries extracting relatively large quantities of a given SRM that are not indicated in export data.

5.2. Recommendations

The green energy transition and the global demand for critical minerals has presented and is presenting a new momentum to identify and respond to supply chain issues that impact children in particular. Given the nature of information about the ASM sector, it is likely that ASM activity as well as other illegal and informal mining activities within critical mineral extraction are underreported. Thus, the number of child labourers and exploitation within critical mineral exploitation is likely to also fall prey to the biased undercount of child labourers.

Considering the difficulty of collecting and accessing critical data and information regarding the issue of child labour in the extraction of critical minerals, the complex global political and legal context of the critical mineral supply chain, and the lack of transparency in the supply chain overall, our main recommendations are as follows:

1. Raise awareness regarding the complexity and risks of the critical supply chain to ensure a just transition. This awareness should be directed at advocacy efforts, policy recommendations, and future research.
2. Encourage collaboration between different stakeholders, particularly children's rights organisations, cooperations, and governments.
3. Conduct further research on the issue of child labour and exploitation within the extraction of critical minerals.

The reality of the critical mineral supply chain and its political importance is that it is complex and there needs to be active and collaborative efforts to understand the supply chain and its risks to human and particularly child well-being better. There are policy efforts, such as the ones built on the fourth generation of mining codes, and efforts to establish corporate social responsibility within the mining sector [127]; nevertheless, the reality of the mineral supply chain is too opaque to ensure that these efforts become reality in all steps of the supply chain. For this purpose, we have specific recommendations for future research:

1. Identify the exact patterns of child labour and other forms of exploitation in key areas (e.g., is child labour occurring in the extraction process or around the mines? Is sexual exploitation of children also an issue in these areas?).
2. Document these changes over time, in line with global trends.
3. Furthermore, for this type of research as well as research with other foci within the topic of SRMs and critical minerals, we recommend:
    a. Understanding which minerals are being extracted at known ASM sites, particularly where minerals co-occur. This means monitoring geological explorations in the country of interest and of certain mineral reserves.
    b. Understanding how mining industries have changed the surrounding communities and their economic activities. Past case studies have indicated that the opening of large-scale and small-scale mining operations influence economic activities around the mining site and are associated with an increase in the occurrence of sexually transmitted infections and an increase in substance use. All of these changes influence children and their vulnerability to exploitation of all forms.
4. Work towards interdisciplinary collaboration with experts from various fields. As well as the need for a robust understanding of mining processes and mineral resource occurrence and management, to understand the industry sufficiently, expertise in social development, climate change, and the private sector is crucial. The intersection of multiple perspectives within one research project is still widely lacking in the current discourse of critical minerals. Specifically, a perspective on social impact on

local communities—and particularly children—is extremely scarce and needs more attention.

6. Conclusions

The findings of this qualitative assessment show that there is a considerable risk of child labour occurring in the critical mineral extraction industry where artisanal small-scale mines are present, particularly among the top exporting countries. High-risk countries include the DRC, Mozambique, India, Myanmar, Madagascar, the Philippines, and Indonesia. Minerals with the highest risk of child labour include cobalt, copper, graphite, nickel, aluminium, and REEs. While it cannot categorically be concluded that child labour is present at the extraction sites of all the above-mentioned SRMs, it does indicate a risk of child labour occurring and calls for further research in collaboration with local organisations, communities, and experts. The findings highlight the importance of understanding the context of the critical mineral industry (and other related industries, e.g., gold), and putting this understanding into action by supporting communities and giving them the resources they need to protect children from an increased vulnerability to child labour. It highlights the general negative impact that mining has on communities and the heightened vulnerability it creates for other forms of child exploitation around the mines, including, but not limited, to sexual exploitation and child trafficking.

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Abbreviations

The following abbreviations are used in this manuscript:

ASM	Artisanal Small-Scale Mine
DRC	Democratic Republic of the Congo
EU	European Union
REE	Rare Earth Elements
SRM	Strategic Raw Material

Appendix A

Table A1. Vulnerability and severity factors for child labour in the mining of cobalt in the DRC.

Type of Factor	Factor	Impact on Risk	Description
Vulnerability factor	Occurrence of modern human slavery, forced labour, and child labour	High	In the context of the DRC, there is a high vulnerability towards modern-day human slavery, and there has only been minimal advancement in the elimination of child and forced labour, with reports of child labour in the extractive industries of cobalt and other critical minerals [21,24].
	Known presence of ASM or illegal mining operations	High	According to the EPRM [58], cobalt is being extracted in the DRC by ASM. Other sources confirm the presence of ASM in the cobalt industry of DRC [84,124].
	Climate change impact in the specific country and/or region	Medium	Climate change in the DRC is a major threat to the agricultural sector [30].
	Economic dependence on threatened industries	Low (based on dependence on previous factor)	A total of 56.07% of the labour force is employed within the agricultural sector [30].
	Poverty levels	Middle	A total of 92.1% of the population lives on less than USD 3.65 a day [30].
	Other contextual factors	Low to middle	There is a high number of displaced and orphaned children [46,47]. Displaced children are considered to be at a higher risk of labour exploitation, exploitation for commercial sex work, and use in illicit activities. Children in conflict areas of the DRC are considered to be at risk of recruitment for non-state armed forces. Further, children with a heritage of certain ethnic groups (Bayakhas, Pygmies, and Bakete) are at an increased risk of child labour and trafficking [24]. Lastly, armed militias are known to have control over mineral mines [84].
Severity factors	Education statistics	Middle	A total of 64.63% of primary-school-age children are out of school, with a learning poverty rate of 86.02% [30].
	Reports of environmental impact of mining	Middle	There is evidence of severe pollution caused by cobalt and copper mines, including water and soil pollution, water decolourisation, and dead animals, which has led to a severe drinking water crisis and sever human health effects [128–130].
	Reports of displacement for mining projects	Middle	Reports of displacement and land expropriation [129].
	Reports of illegal natural resource industry	High	ASM activities in DRC are widely illegal [84].

Table A2. Vulnerability and severity factors for child labour in the mining of copper in the DRC.

Type of Factor	Factor	Impact on Risk	Description
Vulnerability factor	Occurrence of modern human slavery, forced labour, and child labour	High	In the context of the DRC, there is a high vulnerability of modern-day human slavery, and there has only been minimal advancement in the elimination of child and forced labour, with reports of child labour in the extractive industries of copper and other critical minerals [21,30].
	Known presence of ASM or illegal mining operations	High	According to the EPRM [58], copper is being extracted in the DRC by ASM. Other sources confirm the presence of ASM in the copper industry of the DRC [84,124].
	Climate change impact in the specific country and/or region	Medium	Climate change in the DRC is a major threat to the agricultural sector [30].

Table A2. *Cont.*

Type of Factor	Factor	Impact on Risk	Description
Vulnerability factor	Economic dependence on threatened industries	Low *(based on dependence on previous factor)*	A total of 56.07% of the labour force is employed within the agricultural sector [23].
	Poverty levels	Middle	A total of 92.1% of the population lives on less than USD 3.65 a day [30].
	Other contextual factors	Low to middle	There is a high number of displaced and orphaned children [46,47]. Displaced children are considered to be at a higher risk of labour exploitation, exploitation for commercial sex work, and use in illicit activities. Children in conflict areas of the DRC are considered to be at risk of recruitment for non-state armed forces. Further, children with a heritage of certain ethnic groups (Bayakhas, Pygmies, and Bakete) are at an increased risk of child labour and trafficking [17]. Lastly, armed militias are known to have control over mineral mines [84].
Severity factors	Education statistics	Middle	A total of 64.63% of primary-school-age children are out of school, with a learning poverty of 86.02% [30].
	Reports of environmental impact of mining	Middle	There is evidence of severe pollution caused by cobalt and copper mines, including water and soil pollution, water decolourisation, and dead animals, which has led to a severe drinking water crisis and sever human health effects [128–130].
	Reports of displacement for mining projects	Middle	Reports of displacement and land expropriation [129].
	Reports of illegal natural resource industry	High	ASM activities in DRC are widely illegal [84].

Table A3. Vulnerability and severity factors for child labour in the mining of nickel in Indonesia.

Type of Factor	Factor	Impact on Risk	Description
Vulnerability factor	Occurrence of modern human slavery, forced labour, and child labour	High	In 2023, only moderate advancement in the elimination of child labour was reported, with reports of child labour in other extractive industries, including tin. Further, there are reports of forced labour in nickel mining [24]. Berthet and colleagues [21] report a moderate vulnerability towards modern-day human slavery within the mining sector in Indonesia.
	Known presence of ASM or illegal mining operations	High	There are reports of ASM activity in the extraction of nickel in Indonesia [58].
	Climate change impact in the specific country and/or region	Medium	The World Bank [131] indicates Indonesia as highly vulnerable towards climate change.
	Economic dependence on threatened industries	Low (based on dependence on previous factor)	A total of 29.28% of the labour force depends on agriculture [30], and another 12 million depend on fishing for their livelihood [132].
	Poverty levels	Middle	A total of 17.5% of the population lives on less than USD 3.65 a day [30].
	Other	Low to middle	Reports of families being cut off from governmental benefits in response to parents opposing mining activities [133].
Severity factors	Education statistics	Middle	The learning poverty rate is at 35.39% [30].
	Reports of environmental impact of mining	Middle	Reports of pollution caused by nickel extraction which risks the livelihoods of families [65,66,132,133].
	Reports of displacement for mining projects	Middle	Reports of displacement and land expropriation [65,66,133].

Table A4. Vulnerability and severity factors for child labour in the mining of nickel in the Philippines.

Type of Factor	Factor	Impact on Risk	Description
Vulnerability factor	Occurrence of modern human slavery, forced labour, and child labour	High	In 2023, only moderate advancement in the elimination of child labour was reported, with reports of child labour in other extractive industries [24]. Berthet and colleagues [21] report a moderate vulnerability towards modern-day human slavery within the mining sector in the Philippines.
	Known presence of ASM or illegal mining operations	High	There are reports of ASM activity in the extraction of nickel in the Philippines [58].
	Climate change impact in the specific country and/or region	Medium	The Philippines is projected to be considerably impacted by climate change [30]. The effects include increased and more extreme rainfall, coral loss, declining rice yields, more intense droughts, higher sea level rise, and water scarcity [134].
	Economic dependence on threatened industries	Low (based on dependence on previous factor)	A total of 23.71% of the labour force depends on agriculture [30].
	Poverty levels	Middle	A total of 17.8% of the population lives on less than USD 3.65 a day [30].
	Other	Low to middle	The nickel industry in the Philippines has been accused of labour rights abuses [77]. There are reports of alleged abuse of exploration licences for nickel [135]. Voices opposing mining projects are met by police intervention [80,136].
Severity factors	Education statistics	Middle	The regional average for learning poverty is at 32.5% in the Philippines [30]. This is likely due to the challenges experienced within the educational system in the Philippines [137,138].
	Reports of environmental impact of mining	Middle	Nickel mining has been associated with a number of negative outcomes, including health risks and direct negative effects on the environment [70,71,133].
	Reports of displacement for mining projects	Middle	Reports of local populations losing land due to nickel mining projects. One fifth of the Philippines' landmass is covered by mining or exploration permits [139].
	Reports of illegal natural resource industry	High	Reports of illegal mining activities [80,135].

Table A5. Vulnerability and severity factors for child labour in the mining of graphite in Mozambique.

Type of Factor	Factor	Impact on Risk	Description
Vulnerability factor	Occurrence of modern human slavery, forced labour, and child labour	High	Moderate advancement in the elimination of forced and child labour, with reports of children engaging in artisanal small-scale mining [24].
	Known presence of ASM or illegal mining operations	High	EPRM [58] reports ASM activity in graphite extraction in Mozambique.
	Climate change impact in the specific country and/or region	Medium	Mozambique is considered as one of the most affected countries in regard to climate change, with severe effects on agricultural activity [88,90]. According to their Climate Risk Index score, Mozambique is among the top 10 countries most affected by climate change [30,88].
	Economic dependence on threatened industries	Low (based on dependence on previous factor)	A total of 70% of all Mozambiquans are employed within the agricultural sector [30].
	Poverty levels	Middle	Mozambique is categorised as a low-income country, with 49% of children living in extreme poverty [30].

Table A5. *Cont.*

Type of Factor	Factor	Impact on Risk	Description
Vulnerability factor	Other contextual factors	Low to middle	(1) Vulnerable context for children, with 2 million children being parentless and high numbers of child trafficking, child sexual exploitation, and child marriage [93,94,140]. (2) There is a high prevalence of HIV in girls, which indicates an increased vulnerability towards child sexual exploitation [94]. (3) The region in which graphite mining takes place in Mozambique is facing severe issues with a violent conflict [87,92,141,142]. (4) Reports of juvenile labour and trafficking in Mozambique's mining industry [143].
Severity factors	Education statistics	Middle	Low school attendance and attainment, with reports of high prevalence of verbal, physical and sexual abuse in schools [30].
	Reports of environmental impact of mining	Middle	Reports of pollution by large-scale graphite mines in Mozambique [144].
	Reports of displacement for mining projects	Middle	Reports of community displacement for large-scale graphite mines in Mozambique. Further, there are reports of land dispossessions and silencing of activists [144].
	Reports of illegal natural resource industry	High	Large-scale mining operators report illegal mining activities close to their mining sites [145].

Table A6. Vulnerability and severity factors for child labour in the mining of graphite in Madagascar.

Type of Factor	Factor	Impact on Risk	Description
Vulnerability factor	Occurrence of modern human slavery, forced labour, and child labour	High	In 2023, only moderate advancement in the elimination of child labour was reported, with reports of child labour in other extractive industries [24].
	Known presence of ASM or illegal mining operations	High	There are reports of ASM activity in the extraction of graphite in Madagascar [58,84].
	Climate change impact in the specific country and/or region	Medium	Madagascar is considered the fourth most at-risk country concerning climate change, with increasing frequency, duration, and intensity of droughts and cyclones [146].
	Economic dependence on threatened industries	Low (based on dependence on previous factor)	Over 85% of the labour force is dependent on agriculture [30].
	Poverty levels	Middle	A total of 92.4% of the population lives on less than USD 3.65 a day [30].
Severity factors	Education statistics	Middle	A total of 96.72% of children are considered learning-poor [30].
	Reports of environmental impact of mining	Middle	Regions in which graphite is mined are considered to be the most affected by severe droughts, which have resulted in food insecurity. The exploration activities have dried out already-scarce water resources more rapidly than anticipated [98].
	Reports of displacement for mining projects	Middle	No report of displacements but reports of an existing risk of displacement [147].
	Reports of illegal natural resource industry	High	Large-scale mining operators report illegal mining activities close to their mining sites [145].

Table A7. Vulnerability and severity factors for child labour in the mining of REEs in Myanmar.

Type of Factor	Factor	Impact on Risk	Description
Vulnerability factor	Occurrence of modern human slavery, forced labour, and child labour	High	In 2023, there was no advancement in the elimination of child labour, with reports of child labour in other extractive industries [24]. Berthet and colleagues [21] report a moderate-to-high vulnerability towards modern-day human slavery within Myanmar.

Table A7. *Cont.*

Type of Factor	Factor	Impact on Risk	Description
Vulnerability factor	Climate change impact in the specific country and/or region	Medium	Myanmar is already ranked as the second most at-risk country for climate change [105] and has ranked high for the past two decades [107]. Climate hazard risks include floods, cyclones, extreme heat, and landslides. At particular risk are people who rely on agriculture, fishing, and forestry for their livelihoods [106].
	Economic dependence on threatened industries	Low (based on dependence on previous factor)	A total of 45.54% of the labour force depends on agriculture [30].
	Poverty levels	Middle	A total of 19.6% of the population lives on less than USD 3.65 a day [30].
	Other contextual factors	Low to middle	(1) Violent insurgency puts children in the entire country at risk of forced displacement and being exposed to the risks of a violent conflict, including attacks, forcible recruitment, early and forced marriages, arbitrary arrests, detention, abuse, and deprivation of critical services, such as education and health [110]. (2) An investigation by Global Witness [101] revealed human rights abuses, reports of child labour, the control of violent groups, and illegal activities in the REE extraction in Myanmar.
Severity factors	Education statistics	Middle	The regional average for learning poverty is 32.5% [30].
	Reports of environmental impact of mining	Middle	The REE extraction in Myanmar has an extensive impact on the environment. Reports include severe water pollution affecting drinking water sources and poisoning livestock [101].
	Reports of displacement for mining projects	Middle	Reports of illegal land-grabbing [101].
	Reports of illegal natural resource industry	High	The extraction of REE in Myanmar is illegal. There are no official mining licences that have been issued for the new REE mining sites that have been opened since the coup. Further, the extraction of REE by companies from other countries is also illegal. There are reports of REE smuggling [148].

Table A8. Vulnerability and severity factors for child labour in the mining of aluminium in India.

Type of Factor	Factor	Impact on Risk	Description
Vulnerability factor	Occurrence of modern human slavery, forced labour, and child labour	High	There has been moderate advancement in the elimination of child and forced labour in India, with reports of child labour in mining and quarrying [24]. Berthet and colleagues [21] report a moderate-to-high vulnerability towards modern-day slavery in the extractive industry of India.
	Known presence of ASM	High	The EPRM [58] reports the presence of ASM activity in the extraction of Bauxite.
	Climate change impact in the specific country and/or region	Medium	Climate change is having a strong impact on India [30]. The expected and experienced impacts include increasing temperatures, drought, and falling groundwater levels [116].
	Economic dependence on threatened industries	Low (based on dependence on previous factor)	A total of 43% of the labour force is employed within the agricultural sector [30].
	Poverty levels	Middle	A total of 44% of the population live on less than USD 3.65 a day [30].
	Other contextual factors	Low to middle	(1) In the past, there have been reports of child labour around bauxite mining sites [118]. (2) Local communities report that they are scared to report on child labour [118].
Severity factors	Education statistics	Middle	Learning poverty rate at 55% [30].
	Reports of environmental impact of mining	Middle	Reports of pollution due to bauxite mining date back a decade [149].
	Reports of displacement for mining projects	Middle	Conflicts around land dispossessions for bauxite mining operations in India already date back a decade [150].
	Reports of illegal natural resource industry	High	Reports of a mining mafia and illegal mining activity in the bauxite industry mafias [35,58,113–115].

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